IMPACT ANALYSIS

2005 UPDATE TO THE CALIFORNIA ENERGY EFFICIENCY STANDARDS

for RESIDENTIAL and NONRESIDENTIAL BUILDINGS

CALIFORNIA ENERGY COMMISSION

COMMISSION REPORT

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Contract 400-01-023

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Executive Summary

This report estimates the statewide impacts of proposed changes to the California Energy Efficiency Standards on a regional and statewide basis. The analysis presented here is based in part on the information contained in the reports presented earlier in the proceeding and posted at http://www.energy.ca.gov/2005_standards/documents/index.html.

The estimates are based on an internal draft of the Standards as of June 11, 2003. This draft is substantially similar to the February 4, 2003 review draft.

Table 1 has a summary of the savings. For each year of construction activity (in both newly constructed buildings and alterations to existing buildings) the proposed standards are estimated to reduce the growth in electricity by 479 GWh and to reduce the growth in peak demand by 182.3 MW. In addition, natural gas use is expected to be reduced by 8.9 million therms. The savings will accumulate as the Standards affect each subsequent year of constructions. After two years the savings will double; they will triple after three years and they will be ten times in the tenth year.

The savings result from changes to both the residential and nonresidential standards as well as new requirements for outdoor lighting. The standards affect both newly constructed buildings as well as alterations to existing buildings. Newly constructed buildings (including outdoor lighting) account for about 54.7% of the electricity savings, 60.5% of the demand savings, and 67.5% of the gas savings. Alterations account for the other savings.

Table 1 – Savings Summary

		Electricity		Demand		Gas	
		Savings (GWh)	Percent of Total	Savings (MW)	Percent of Total	Savings (millions therms)	Percent of Total
Newly Constructed Buildings	Low-Rise Residential	98.7	20.6%	66.4	36.4%	5.5	62.5%
	Nonresidential	143.0	29.9%	44.0	24.1%	0.5	5.7%
	Relocatable Classrooms	3.1	0.7%	n. a.	n. a.	0.0	0.0%
	Outdoor Lighting	17.1	3.6%	0.0	0.0%	0.0	0.0%
	Total	262.0	54.7%	110.3	60.5%	6.0	68.2%
Alterations	Low-Rise Residential	41.4	8.7%	26.7	14.7%	3.0	34.0%
	Nonresidential	175.0	36.5%	44.3	24.3%	-0.2	-2.3%
	Total	216.4	45.2%	71.0	39.2%	2.8	31.8%
Grand Total		478.5	100.0%	181.4	100.0%	8.8	100.0%

More detail of the savings is provide in later tables. Electricity energy savings are summarized in Table 2, electric demand savings in Table 3, and gas savings in Table 4.

Newly Constructed Buildings

The first-year savings for single-family homes are 83.6 GWh, 52.1 MW and 3.7 million therms of gas. Most the electricity savings are associated with lighting measures (55.5 GWh), while most of the peak demand savings are related to increased air conditioner efficiency (49.4 MW). For low-rise multi-family buildings, the first-year electricity savings are 15.1 GWh, the first-year demand savings are 14.3 MW, and the first-year gas savings are 1.8 million therms.

Looking at the entire low-rise residential sector, electricity use is reduced by 20.4% compared to the 2001 Standards, peak demand is reduced by 18.3% and gas is reduced by 8.3%. These percent savings are relative to heating, cooling, lighting and water heating only and do not include other appliances, outdoor lighting that is not attached to buildings, plug loads, or other energy uses.

Single-family estimates are based on 108,468 housing starts each year; multi-family estimates are based on 41,732 housing starts. These data are from the Construction Industries Research Board (CIRB). These savings do not include substantial savings expected to occur from additions to residential buildings which must meet the requirements for newly constructed buildings.

Building envelope, HVAC and water heating savings for low-rise residential were calculated using the prototype approach which has been used for previous standards updates and the estimates in this executive summary are based on this approach. The savings for each prototype in each climate were weighted by estimated annual housing starts in each climate to yield an estimate of statewide savings. A second approach was used to calculate savings based on a residential database of 571 single-family homes and 151 multi-family homes. This approach results in an estimate of 40.2 GWh of first-year electricity savings and 5 million therms of first-year gas savings for single-family homes and 7.9 GWh of first-year electricity savings and 1.8 million therms of first-year gas savings for multi-family homes. The prototype approach values are used because they are a more conservative estimate of savings.

The first-year savings for nonresidential buildings are 143.0 GWh, 44.0 MW, and 0.5 million therms of gas, representing reductions from the 2001 Standard of 7.7%, 8.5%, and 3.2%, respectively. The savings for nonresidential buildings were calculated using the nonresidential new construction (NRNC) database. A total of 984 buildings were modeled in minimum compliance with the 2001 and 2005 Standards. The buildings in the database occur in each of the 16 climate zones and represent 13 building types. Each site in the sample has a statistical weight attached to it due to the portion of total construction activity that is represented by that building. Nonresidential savings estimates are based on anticipated annual growth of 159 million ft^2 of newly constructed buildings and additions to existing buildings each year.

The standards also include new provisions for relocatable classrooms. About 3,000 new relocatable classrooms are expected to be constructed each year for the California market. The standards are expected to save 3.1 GWh in the first year. All relocatable classrooms are assumed to be conditioned by heat pumps so there are no gas savings.

The standards regulate outdoor lighting for the first time. First-year electricity savings are estimated to be 17.1 GWh. There is no impact on gas use savings for outdoor lighting. Peak demand savings are not estimated for the outdoor lighting standards since the California system peak generally occurs during August or September late afternoon hours. However, the California winter peak which occurs after dark in the winter can cause serious electricity system problems and the outdoor lighting standards will affect this peak. Rolling blackouts occurred at this time in January 2001. At the winter peak the new outdoor lighting requirements are expected to save 6.3 MW.

Outdoor lighting savings are calculated from a database of outdoor lighting applications collected as part of a CEC Public Interest Energy Research (PIER) project. A basecase lighting power condition was established for each outdoor lighting application (for instance parking lots) and the savings are based on the difference between the basecase condition and the proposed standard. Per unit savings are then weighted by expected construction activity for outdoor lighting across the state. The savings estimates are based on the February 2003 draft of the Standards.

Alternations to Existing Buildings

Savings for alterations to existing buildings are quite significant, representing 45.3% of the total electricity savings. First-year electricity savings are expected to be 216.9 GWh, first-year demand reduction is 71.9 MW and first-year gas savings are 2.9 million therms. First-year savings for alterations to existing buildings in the low-rise residential sector represent 41.9 GWh of electricity, 27.6 MW of peak demand reduction, and 3.1 million therms of gas savings. Alterations to existing buildings in the nonresidential sector represents 175.0 GWh of first-year electricity savings and 44.3 MW of first-year demand savings. Gas use is slightly increased because of the cool roof requirement, which reduces cooling but increases heating slightly.

For single-family and multi-family homes, the savings are due to Standards requirements for window replacements and duct sealing. For nonresidential buildings most of the energy savings are related to improvements in interior lighting, but include savings for duct sealing and cool roofs as well.

Table 2 – Summary of First-Year Electricity Savings (GWh)

	2001 Standard	2005 Standard	Savings	Percent Reduction from Baseline	Percent of Total Savings
Single-Family					
Lighting	233.6	178.1	55.5	23.8%	11.6%
Heating	0.0	0.0	0.0	n. a.	0.0%
Cooling	188.1	160.0	28.1	14.9%	5.9%
Water Heating	0.0	0.0	0.0	n. a.	0.0%
Total	421.7	338.1	83.6	19.8%	17.5%
Multi-Family					
Lighting	39.2	30.1	9.1	23.3%	1.9%
Heating	0.0	0.0	0.0	n. a.	0.0%
Cooling	23.0	17.0	6.0	26.0%	1.3%
Water Heating	0.0	0.0	0.0	n. a.	0.0%
Total	62.2	47.1	15.1	24.3%	2.3%
Low-Rise Residential					
Lighting	272.8	208.1	64.6	23.7%	13.5%
Heating	0.0	0.0	0.0	n. a.	0.0%
Cooling	211.2	177.1	34.1	16.1%	7.1%
Water Heating	0.0	0.0	0.0	n. a.	0.0%
Total	483.9	385.2	98.7	20.4%	20.6%
Nonresidential					
Lighting	861.6	777.5	84.1	9.8%	17.6%
Heating	38.8	36.9	1.9	4.9%	0.4%
Cooling	537.5	501.5	35.9	6.7%	7.5%
Fans	424.7	403.6	21.1	5.0%	4.4%
Total	1,862.6	1,719.5	143.0	7.7%	29.9%
Relocatable Classrooms	37.6	34.5	3.1	8.3%	0.7%
Outdoor Lighting	68.2	51.1	17.1	25.1%	3.6%
Total Newly Constructed Buildings	**2,452.4**	**2,190.3**	**262.0**	**10.7%**	**54.8%**
Low-Rise Residential Alterations					
Fenestration	n. a.	n. a.	6.3	n. a.	1.3%
Duct Sealing	n. a.	n. a.	35.1	n. a.	7.3%
Total	n. a.	n. a.	41.4	n. a.	8.7%
Nonresidential Alterations					
Interior Lighting	1,544.5	1,393.8	150.7	9.8%	31.5%
Ducts	n. a.	n. a.	9.7	n. a.	2.0%
Cool Roofs	n. a.	n. a.	14.6	n. a.	3.1%
Total	n. a.	n. a.	175.0	n. a.	36.6%
Total Alterations	**n. a.**	**n. a.**	**216.4**	**n. a.**	**45.2%**
Grand Total	**n. a.**	**n. a.**	**478.5**	**n. a.**	**100.0%**

Note: n. a. means that the data is not available or cannot be calculated

Table 3 – Summary of First-Year Electric Demand Savings (MW)

	2001 Standard	2005 Standard	Savings	Percent Reduction from Baseline	Percent of Total Savings
Single-Family					
Lighting	15.0	12.2	2.7	18.3%	1.5%
Heating	0.0	0.0	0.0	n. a.	0.0%
Cooling	291.7	242.4	49.4	16.9%	27.2%
Water Heating	0.0	0.0	0.0	n. a.	0.0%
Total	306.7	254.6	52.1	17.0%	28.7%
Multi-Family					
Lighting	2.2	1.9	0.3	12.4%	0.2%
Heating	0.0	0.0	0.0	n. a.	0.0%
Cooling	53.0	39.0	14.0	26.4%	7.7%
Water Heating	0.0	0.0	0.0	n. a.	0.0%
Total	55.2	40.9	14.3	25.8%	7.9%
Low-Rise Residential					
Lighting	17.2	14.2	3.0	17.5%	1.7%
Heating	0.0	0.0	0.0	n. a.	0.0%
Cooling	344.7	281.4	63.3	18.4%	34.9%
Water Heating	0.0	0.0	0.0	n. a.	0.0%
Total	361.9	295.5	66.4	18.3%	36.6%
Nonresidential					
Lighting	157.9	142.6	15.3	9.7%	8.4%
Heating	3.6	3.5	0.1	2.2%	0.0%
Cooling	276.7	253.1	23.6	8.5%	13.0%
Fans	79.7	74.6	5.0	6.3%	2.8%
Total	517.9	473.9	44.0	8.5%	24.3%
Relocatable Classrooms	n. a.	n. a.	n. a.	n. a.	n. a.
Outdoor Lighting	n. a.	n. a.	0.0	n. a.	0.0%
Total Newly Constructed Buildings	**879.8**	**769.4**	**110.3**	**12.5%**	**60.8%**
Low-Rise Residential Alterations					
Fenestration	n. a.	n. a.	2.4	n. a.	1.3%
Duct Sealing	n. a.	n. a.	24.3	n. a.	13.4%
Total	n. a.	n. a.	26.7	n. a.	14.7%
Nonresidential Alterations					
Interior Lighting	283.0	255.6	27.4	9.7%	15.1%
Ducts	n. a.	n. a.	7.4	n. a.	4.1%
Cool Roofs	n. a.	n. a.	9.5	n. a.	5.2%
Total	n. a.	n. a.	44.3	n. a.	24.4%
Total Alterations	**n. a.**	**n. a.**	**71.0**	**n. a.**	**39.2%**
Grand Total	**n. a.**	**n. a.**	**181.4**	**n. a.**	**100.0%**

Note: n. a. means that the data is not available or cannot be calculated

Table 4 – Summary of First-Year Gas Savings (millions Therms)

	2001 Standard	2005 Standard	Savings	Percent Reduction from Baseline	Percent of Total Savings
Single-Family					
Lighting	0.0	0.0	0.0	n. a.	0.0%
Heating	28.0	27.4	0.6	2.2%	6.9%
Cooling	0.0	0.0	0.0	n. a.	0.0%
Water Heating	26.9	23.8	3.1	11.5%	35.0%
Total	54.9	51.2	3.7	6.7%	41.8%
Multi-Family					
Lighting	0.0	0.0	0.0	n. a.	0.0%
Heating	2.9	2.6	0.3	9.5%	3.1%
Cooling	0.0	0.0	0.0	n. a.	0.0%
Water Heating	8.7	7.1	1.5	17.8%	17.5%
Total	11.6	9.8	1.8	15.7%	20.6%
Low-Rise Residential					
Lighting	0.0	0.0	0.0	n. a.	0.0%
Heating	30.9	30.0	0.9	2.9%	10.0%
Cooling	0.0	0.0	0.0	n. a.	0.0%
Water Heating	35.6	30.9	4.6	13.0%	52.5%
Total	66.5	61.0	5.5	8.3%	62.5%
Nonresidential					
Lighting	0.0	0.0	0.0	n. a.	0.0%
Heating	15.3	14.8	0.5	3.1%	5.4%
Cooling	0.3	0.3	0.0	10.4%	0.4%
Fans	0.0	0.0	0.0	n. a.	0.0%
Total	15.6	15.1	0.5	3.2%	5.7%
Relocatable Classrooms	n. a.	n. a.	0.0	n. a.	0.0%
Outdoor Lighting	n. a.	n. a.	0.0	n. a.	0.0%
Total Newly Constructed Buildings	**82.1**	**76.1**	**6.0**	**7.3%**	**68.2%**
Low-Rise Residential Alterations					
Fenestration	n. a.	n. a.	0.3	n. a.	3.4%
Duct Sealing	n. a.	n. a.	2.7	n. a.	30.6%
Total	n. a.	n. a.	3.0	n. a.	34.0%
Nonresidential Alterations					
Interior Lighting	n. a.	n. a.	0.0	n. a.	0.0%
Ducts	n. a.	n. a.	0.0	n. a.	0.0%
Cool Roofs	n. a.	n. a.	-0.2	n. a.	-2.3%
Total	n. a.	n. a.	-0.2	n. a.	-2.3%
Total Alterations	**n. a.**	**n. a.**	**2.8**	**n. a.**	**31.8%**
Grand Total	**n. a.**	**n. a.**	**8.8**	**n. a.**	**100.0%**

Note: n. a. means that the data is not available or cannot be calculated

Newly Constructed Buildings

This section describes the impact of the standards on newly constructed buildings.[1] Newly constructed buildings tare buildings that have never before been used or occupied. Newly constructed buildings are a subset of new construction, which includes alterations and additions.

Residential Lighting

Standards Requirements

The proposed Standards require high efficacy luminaries with exceptions that allow automatic controls in some spaces. These requirements are contained in §150(k) of the proposed 2005 Standards.

Methodology

Two prototype buildings were used to estimate lighting energy savings. For single-family, the CEC worked with CBIA to develop lighting system takeoffs from blueprints of a representative 2,200 ft² single-family home. For multi-family buildings, a lighting design was developed for the prototype multi-family building used in the analysis of HVAC and building envelope measures. The prototypes were used to determine the types of lighting systems and controls typically used in newly constructed single-family homes and multi-family dwelling units in California. For each prototype, the following information was determined:

- Rooms and spaces with hardwired lighting.
- Lighting fixtures and lamps per room/space.
- Mounting type for each fixture (surface, recessed, bath bar, wall, pendant).
- Lamp types (Incandescent, fluorescent).
- Control types that would comply with the 2005 Standards.

Recent comments from energy consultants indicate that builders often continue to fail to comply with the 2001 kitchen lighting standards.[2] To study this issue, the CEC developed two baseline conditions for each prototype. The first condition is a non-compliant case that does not meet the 2001 Standards for kitchen lighting. The second condition is a compliant case that meets the 2001 Standards. The savings in this report are based on the compliant case, which produces a conservative impact estimate.

Analysis and Detailed Results

Energy Use. Based on the prototype analysis, a typical single family home in compliance with the 2001 Standards is estimated to have annual electricity use of 2,153 kWh/dwelling unit (du) and this would be reduced to 1,642 kWh/du under the 2005 Standards. This represents a savings of 23.8% A typical multi-family dwelling unit in compliance with the 2001 Standards is estimated to have annual electricity use of 939 kWh/du and this would be reduced to 720 kWh/du under the 2005 Standards; this represents a 23.3% savings.

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[1] The California Building Code (Section 1102A) uses the term "newly constructed building" to mean "a building that has never before been used or occupied for any purpose."

[2] The Commission has received comments in the past that the Standards requirements for kitchen lighting lack clarity. The Commission provided clarification of the kitchen requirements in Blueprint #62 (Spring 2000). This clarification was incorporated in the Residential Manual that was approved by the Commission for the 2001 Standards.

Connected Lighting Power. For the prototype single-family home, connected lighting power (not accounting for controls or diversity) would be reduced from 2,364 W/du to 2,115 W/du. For the multi-family prototype, connected lighting power (also not accounting for controls, coincident peak or diversity) would be reduced from 898 W/du to 841 W/du. With consideration of automatic controls and eliminating porch lights (assumed to be off during the peak hour), the power reduction for single-family is reduced from 2,139 W/du to 1,707 W/du. For multi-family, the reduction is from 823 W/du to 712 W/du.

Coincident Peak Savings. To determine coincident peak demand reduction, the power savings (adjusted for controls and porch lights) is modified by a load profile for residential lighting obtained from the CEC. [3] The hour of coincident peak demand varies slightly by climate zone because of differences in the peak hour for each climate zone. Figure 1 shows the hourly schedule used to determine coincident peak demand. During the coincident peak, power in the single-family prototype would be reduced either 22 W or 26 W per dwelling unit, depending on climate zone.[4] See Table 7 for details. Peak demand for the multi-family prototype would be reduced by either 7 W or 9 W per dwelling unit, depending on climate zone. See Table 8 for details.

Statewide Savings. The per dwelling unit energy and demand savings are combined with projected housing starts to estimate the statewide impact of energy savings and peak demand reduction. This data is summarized in Table 9. Residential lighting energy is estimated to be reduced by 64.6 GWh, with 55.5 GWh associated with single-family homes and 9.1 GWh with multi-family homes. Peak demand is reduced by 3.0 MW, with 2.7 MW coming from single-family homes and 0.3 MW from multi-family homes.

The estimates of lighting energy savings and peak demand reductions do not account for the secondary effects of reduced cooling load. As lighting power is reduced, less heat is generated within conditioned space. This will reduce cooling energy, but slightly increase heating energy.

Table 5 – Annual Hours of Operation for Residential Lighting

Lighting Application	Annual Hours of Operation (hours)	Notes
Outdoor - Front Porch	2,190	Assume 6 hours/day X 365
Outdoor - Back Porch, Garage Porch	730	Assume 2 hours/day X 365
Kitchen, Nook, Dining	1,241	
Entry, Hall, Stairs	803	
Bath, Powder	730	
Utility	949	
Walk-in closet	365	Assume 1 hour/day X 365
Source: Volume I, California Baseline (Lighting Efficiency Technology Report, CEC Contract #400-95-012, May 30, 1997), Figure 1.6 - Average Hours of Operation by Room Type.		

Table 6 – Summary of Lighting Control Savings

Space Type	Control Type	Demand Savings (kW)	Energy Savings (kWh)
Support Spaces	Motion Sensor	10%	10%
Bathrooms	Motion Sensor	20%	20%
Outside	PV/Motion Sensor	Not included in savings	50%
Other Spaces	Dimmer	10%	10%

[3] Volume I, California Baseline (Lighting Efficiency Technology Report. CEC Contract #400-95-012, May 30, 1997).

[4] The time of the coincident peak varies with climate zone since it is driven by air conditioning load and the fraction of the lights that are on depends on time of day. This combination of factors results in a coincident peak equaling 11.9% of the connected load savings for climate zones 2 through 5 and 7 through 9 and 14.3% of the connected load in other climates.

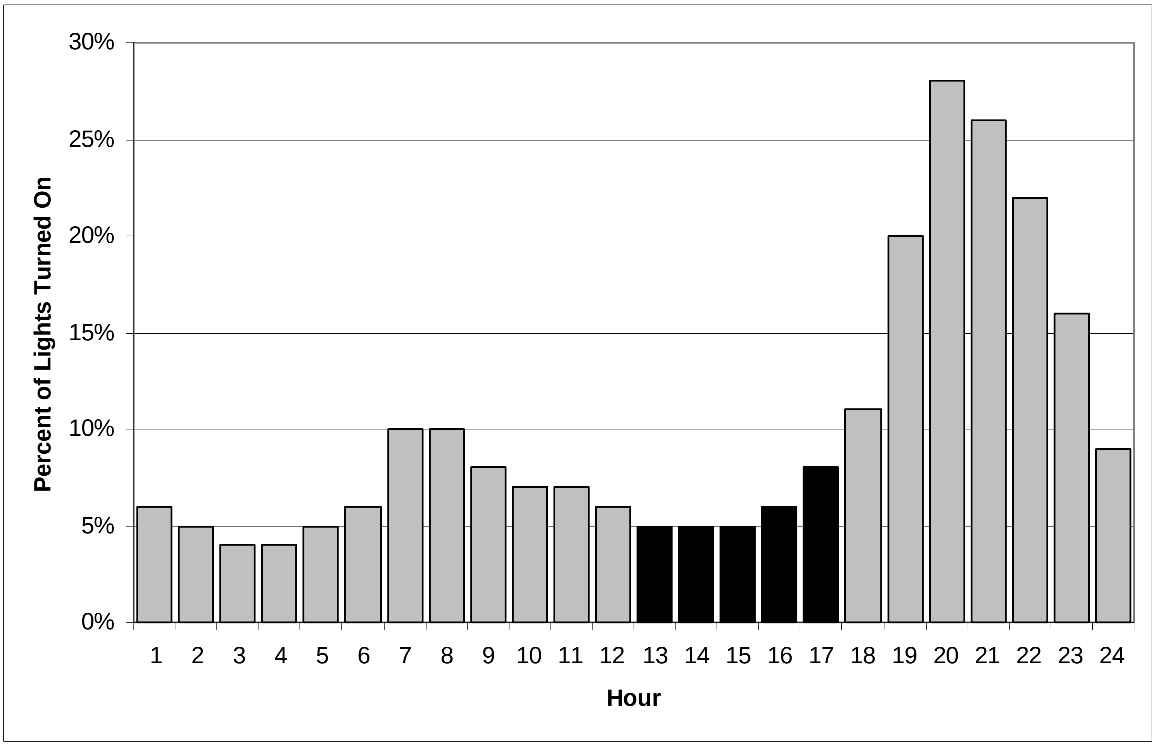

Figure 1 – Hourly Lighting Schedule
Maximum TDV Occurs at Hours 13 through 17 in August or September.

Table 7 – Lighting Energy and Power First-Year Savings for Typical Single-Family Home

					2001 Compliant				2005 Compliant						Savings	
Location	Number	Mounting	Lamp	Hours/year	Watts / Luminaire	Connected Power (W)	Connected Power Adjusted for Con trols and No Porch Lights (W)	Annual Electricity Use (kWh)	Watts / Luminaire	Automatic Control	Control Reduction Factor	Connected Power (W)	Connected Power Adjusted for Con trols and No Porch Lights (W)	Annual Electricity Use (kWh)	Electricity Savings (kWh/y-du)	Connected Power Savngs (W)
Entry Porch	1	Recessed	Fluorescent	2,190	75	75	0	164	18	None	100%	18	0	39	125	0
Back Porch	1	Wall	Incandescent	730	75	75	0	55	75	Photo/Motion	50%	75	0	27	27	0
Garage Porch	1	Wall	Incandescent	730	75	75	0	55	75	Photo/Motion	50%	75	0	27	27	0
Kitchen (Genl)	4	Recessed	Fluorescent	1,241	18	72	72	89	18	None	100%	72	72	89	0	0
Kitchen (Task)	1	Recessed	Fluorescent	1,241	18	18	18	22	18	None	100%	18	18	22	0	0
Nook	2	Recessed	Incandescent	1,241	75	150	150	186	75	Dimmer	90%	150	135	168	19	15
Dining	4	Recessed	Incandescent	1,241	75	300	300	372	75	Dimmer	90%	300	270	335	37	30
Entry	1	Recessed	Incandescent	803	75	75	75	60	75	Occupancy	80%	75	60	48	12	15
Powder	1	Bath Bar	Incandescent	730	160	160	160	117	160	Occupancy	80%	160	128	93	23	32
Powder	1	Ceiling	Fluorescent	730	18	18	18	13	18	None	100%	18	18	13	0	0
Hall 1	1	Recessed	Incandescent	803	75	75	75	60	75	Occupancy	90%	75	68	54	6	8
Laundry	1	2x4	Fluorescent	949	80	80	80	76	59	None	100%	59	59	56	20	21
Garage	1	Wall	Incandescent	840	75	75	75	63	75	Occupancy	90%	75	68	57	6	8
Stairs	1	Recessed	Fluorescent	803	75	75	75	60	18	None	100%	18	18	14	46	57
Hall 2	3	Recessed	Incandescent	803	75	225	225	181	75	Occupancy	90%	225	203	163	18	23
Hall 3	2	Recessed	Incandescent	803	75	150	150	120	75	Occupancy	90%	150	135	108	12	15
Bath 2	1	Ceiling	Fluorescent	730	18	18	18	13	18	None	100%	18	18	13	0	0
Bath 2	1	Bath Bar	Incandescent	730	240	240	240	175	240	Occupancy	80%	240	192	140	35	48
Master Bath	1	Ceiling	Fluorescent	730	18	18	18	13	18	None	100%	18	18	13	0	0
Master Bath	1	Bath Bar	Incandescent	730	240	240	240	175	240	Occupancy	80%	240	192	140	35	48
Master Toilet	1	Ceiling	Fluorescent	730	75	75	75	55	18	None	100%	18	18	13	42	57
Master WIC	1	Ceiling	Fluorescent	365	75	75	75	27	18	None	100%	18	18	7	21	57
						2,364	**2,139**	**2,153**				**2,115**	**1,707**	**1,642**	**511**	**433**
															23.8%	**20.2%**

Table 8 – Lighting Energy and Power First-Year Savings for Typical Multi-Family Dwelling Unit

					2001 Compliant				2005 Compliant						Savings	
Location	Number	Mounting	Lamp	Hours/year	Watts / Luminaire	Connected Power (W)	Connected Power Adjusted for Con trols and No Porch Lights (W)	Annual Electricity Use (kWh)	Watts / Luminaire	Automatic Control	Control Reduction Factor	Connected Power (W)	Connected Power Adjusted for Con trols and No Porch Lights (W)	Annual Electricity Use (kWh)	Electricity Savings (kWh/y-du)	Connected Power Savngs (W)
Entry Porch	1	Recessed	Fluorescent	2,190	75	75	0	164	18	None	100%	18	0	39	125	0
Kitchen (Genl)	4	Recessed	Fluorescent	1,241	18	72	72	89	18	None	100%	72	72	89	0	0
Kitchen (Task)	1	Recessed	Fluorescent	1,241	18	18	18	22	18	None	100%	18	18	22	0	0
Dining	1	Recessed	Incandescent	1,241	240	240	240	298	240	Dimmer	90%	240	216	268	30	24
Powder	1	Bath Bar	Incandescent	730	160	160	160	117	160	Occupancy	80%	160	128	93	23	32
Hall 1	1	Recessed	Incandescent	803	75	75	75	60	75	Occupancy	90%	75	68	54	6	8
Bath 2	1	Ceiling	Fluorescent	730	18	18	18	13	18	None	100%	18	18	13	0	0
	1	Bath Bar	Incandescent	730	240	240	240	175	240	Occupancy	80%	240	192	140	35	48
						898	**823**	**939**				**841**	**712**	**720**	**219**	**112**
															23.3%	**13.5%**

Table 9 – Statewide Residential Lighting Energy and Demand First-year Savings by Climate Zone

		Single Family				Multi-Family				Total	
Climate Zone	Peak Demand Multiplier	Housing Starts	Demand Reduction (W/du)	Energy Savings (GWh/y)	Reduced Demand (MW)	Housing Starts	Demand Reduction (W/du)	Energy Savings (GWh/y)	Reduced Demand (MW)	Energy Savings (GWh/y)	Reduced Demand (MW)
1	6.0%	422	26	0.2	0.0	89	7	0.0	0.00	0.2	0.0
2	5.0%	3,364	22	1.7	0.1	1,344	6	0.3	0.01	2.0	0.1
3	5.0%	3,909	22	2.0	0.1	3,758	6	0.8	0.02	2.8	0.1
4	8.0%	3,200	35	1.6	0.1	4,596	9	1.0	0.04	2.6	0.2
5	5.0%	1,496	22	0.8	0.0	412	6	0.1	0.00	0.9	0.0
6	6.0%	6,932	26	3.5	0.2	7,978	7	1.7	0.05	5.3	0.2
7	5.0%	6,048	22	3.1	0.1	3,967	6	0.9	0.02	4.0	0.2
8	5.0%	4,141	22	2.1	0.1	1,890	6	0.4	0.01	2.5	0.1
9	5.0%	4,622	22	2.4	0.1	2,575	6	0.6	0.01	2.9	0.1
10	6.0%	15,172	26	7.8	0.4	4,763	7	1.0	0.03	8.8	0.4
11	6.0%	6,618	26	3.4	0.2	1,220	7	0.3	0.01	3.7	0.2
12	6.0%	24,671	26	12.6	0.6	5,154	7	1.1	0.03	13.7	0.7
13	6.0%	9,497	26	4.9	0.2	686	7	0.2	0.00	5.0	0.3
14	6.0%	5,510	26	2.8	0.1	629	7	0.1	0.00	3.0	0.1
15	6.0%	8,810	26	4.5	0.2	1,793	7	0.4	0.01	4.9	0.2
16	6.0%	4,055	26	2.1	0.1	880	7	0.2	0.01	2.3	0.1
		108,468		55.5	2.7	41,732		9.1	0.27	64.6	3.0

Residential Envelope, HVAC and Water Heating

Summary

The impact of implementing the residential envelope, HVAC, and water heating measures of the 2005 Standards was estimated in two ways: the prototype approach and the database approach.

- **Prototype Approach**. This prototype approach was used in the AB 970 impact analysis and in estimating the impact for previous updates to the residential standards. With this approach, two prototypes are used, one for single-family homes and one for multi-family homes. Each prototype is made to minimally comply with the 2001 and 2005 Standards, and the results are weighted by anticipated housing starts in each climate zone.
- **Database Approach**. The second approach is similar to the approach used to evaluate the 2001 and 2005 changes for nonresidential buildings. Instead of using just two prototypes, a database of 573 single-family homes and 151 multi-family buildings is used. Each of the 724 buildings are modeled in minimum compliance with the 2001 and 2005 Standards. Within each climate zone, the per dwelling unit results are averaged. These averages are then weighted according to the portion of anticipated housing starts in each climate that is represented by each building in the database.

The two methods produce somewhat different results. The predictions from the database approach are larger mostly because the average dwelling unit size in the database is larger than the prototypes used in the first approach, and also due to differences in the mapping of building starts to climate zones used in the two approaches. For single-family homes the average house size in the database is 2,319 ft², which is 32% larger than the 1,761 ft² single-family prototype.

Standards Requirements

The Standards changes include new California specific requirements, changes in the federal Appliance Standards for water heaters and air conditioners, and revised compliance procedures. The savings between the 2001 and 2005 Standards are explained by the following measures.

Building Envelope and HVAC Measures

Measure	*Modeling Notes*
• ***Air Conditioner Efficiency.*** New federal requirements for air conditioner efficiency go into effect in January 2006. For air conditioners with a capacity of less than 65,000 Btu/h, the savings are based on the seasonal energy efficiency ratio (SEER) changing to 12.0.	The calculated savings in this impact study assume that the new standards will base the performance standards on the new minimum SEER of 12.0.
• ***Duct Insulation.*** The prescriptive insulation requirement for ducts located outside conditioned space has been raised from the current R-4.2 to R-6 in climate zones 1 through 5, as well as 9 through 13 and to R-8 in climate zones 14, 15 and 16. This change impacts heating and cooling energy use, and cooling peak electricity demand.	For cooling peak demand, the capacity impact of improved air conditioner efficiency and duct insulation is determined using ASHRAE Standard 152 design conditions. Peak demand impact is estimated by assuming that air conditioners are sized correctly with the 2005 standards and that 65% of residential compressors are in use during the peak demand period.

Measure	*Modeling Notes*
• ***Fenestration Area.*** Fenestration area in the prescriptive packages is currently limited to 16% of the floor area (climate zones 1, 2, 5, 11, 12, 13, 14, 15, and 16) and 20% of floor area (climate zones 3, 4, 6, 7, 8, 9, and 10). In the 2005 Standards, the new prescriptive glazing area becomes 20% of the conditioned floor area for all climate zones. With performance calculations, the glass area of the standard design is equal to the proposed design or 20%, whichever is less.	The impact of these changes are included by expanding the prototype analysis to include the distribution of glazing area similar to the database approach. This effect also is modeled with the database approach since each of the 724 sites has a specific window area.
• ***Limit on West-Facing Glazing.*** A new prescriptive requirement for climate zones 2, 4, and 7-15 limits west-facing glazing area to no more than 5% of the floor area. Horizontal and west-facing skylights are defined as west-facing glazing and are included in the 5% limit.	While this requirement is important in reducing peak loads due to residential air conditioning for builders complying prescriptively, it does not change the impact analysis under the ACM performance approach since only standard designs are compared.

Water Heating Measures

The following changes affect energy savings for water heating. The water heating measures do not affect electric demand since only standard designs are compared with both the prototype and database approaches. As defined in the Residential ACM Manual (Draft 2, February 2003), the standard design water heater is either gas or propane. While some of the sites in the database approach have electric water heating, this does not matter since only standard designs are compared.

Measure	*Modeling Notes*
• ***Equipment Efficiency***. The federal energy factor (EF) requirements for storage gas water heaters will change in January 2004. For 50 gallon natural gas water heaters, the required EF is 0.575. See Table 26.	Water heaters are modeled with the higher federal Standard efficiency as the Standard Design for the 2005 Standards.
• ***Multi-Family Standard Design***. The standard design for multi-family dwelling units assumed individual water heaters in each dwelling unit with the 2001 standards. With the 2005 standards, the standard design is a central system if the proposed design has a central system.	With the prototype approach, it is estimated that 40% of multi-family dwelling units have central systems in climate zones 6 through 10, and that 15% have central systems in the other climate zones. For this portion of the population of newly constructed buildings, a central system is assumed in the Standard Design.
• ***Pipe Insulation***. With the 2005 Standards, piping to the kitchen appliances are required to be insulated. No kitchen pipe insulation was required in the 2001 Standards.	No kitchen pipe insulation was modeled with the 2001 and it was added with the 2005 Standards.

Modeling Assumptions, Compliance Options, and Algorithms

The following modeling changes and compliance options are implemented with the proposed 2005 Standards. These modeling assumptions are generally neutral in the analysis, since they are used to estimate energy use and demand for both the 2001 and the 2005 Standards.

- ***Fenestration Performance Ratings*.** The National Fenestration Rating Council (NFRC) introduced updated rating procedures that are being implemented in 2003. The most significant change is a reduction in U-factors and solar heat gain coefficients (SHGC) for metal-framed products. The prescriptive package requirements have been adjusted to be consistent with the rating update, and the updated ratings are used in the energy analysis of both the 2001 and 2005 Standards. The NFRC rating procedure changes apply to nonresidential fenestration also.
- ***New Compliance Options*.** New compliance options have been added for improved residential insulation and building envelope construction quality, improved air conditioner airflow, reduced air handler fan watts, high EER air conditioners, and correct air conditioner sizing. These are expected to be important efficiency measures that will be widely used in compliance, but since they are not prescriptive requirements, they will be traded for other requirements and will not reduce overall energy use.
- ***Hourly Water Heating Calculations*.** The water heating calculation procedures have been modified to produce hourly results to implement the TDV energy approach, and is used for both the 2001 and 2005 Standards. The impact on predicted electricity and gas savings is minimal.
- ***Distribution Losses within Dwelling Units*.** The procedures for calculating distribution losses within dwelling units has been modified. No savings in this analysis has been attributed to these changes.
- ***Distribution Losses for Multi-Family Recirculation Systems*.** Procedures have been added to more accurately account for recirculation system distribution losses in multi-family dwellings. No savings in this analysis has been attributed to these changes.
- ***Time Dependent Valuation (TDV)*.** TDV energy replaces source energy for performance trade-off accounting, and TDV has been implemented in the 2005 version of the ACM manuals and in the calculations used for impact analysis.[5]
- ***Credit for Air Conditioner Efficiency Measures***. The ACM model for air conditioner efficiency measures has been changed based on recent research[6] indicating that a thermal expansion valve (TXV) does not improve the low air performance of a cooling system. The assumption is that all homes comply with the requirement by using a TXV. The impact of the existing requirement for charge testing or TXV in certain climate zones is now modeled as a 7% reduction in compressor energy.
- ***Other Modeling Changes*.**
  - Wall framing factors have been increased from the old assumption of 15% framing to 25% framing based on an ASHRAE/CEC research[7].
  - New hourly models that have been implemented in the 2005 ACM for residential air conditioners, heat pumps, air handler fans, attic ducts, and domestic water heaters.
  - The ACM slab model has been improved by using a seasonal ground temperature instead of assuming losses to outdoor temperature.
  - Assumed ventilation behavior has been changed from the old assumption of 24-hour optimum window operation to windows always being closed from 11 p.m. to 6 a.m.
  - The glazing obstruction factor, which accounts for average site shading not included in the compliance models and other factors, has been adjusted from 0.67 to 0.72.
  - Hourly thermostat settings have changed to better match actual occupancy and residential air conditioning peak demand profiles. The old and new thermostat settings are shown in Figure 2 and Figure 3.

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5 Time Dependent Valuation (TDV) – Economics Methodology, PG&E, April 2, 2002.

6 Pacific Gas and Electric Company, "Nonresidential Duct Sealing and Insulation," Codes and Standards Enhancement Initiative Final Report, May 2003.

7 Enermodal Engineering, Characterization of Framing Factors for Low-Rise Residential Building Envelopes in California, CEC Contract P500-02-002, December 2001

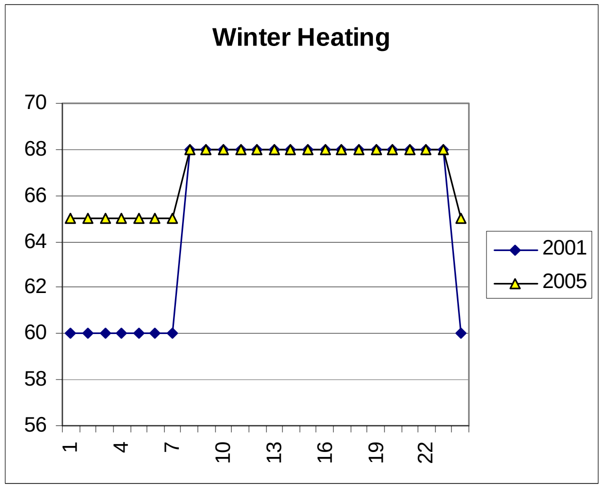

Figure 2 – Low-Rise Residential Heating Thermostats

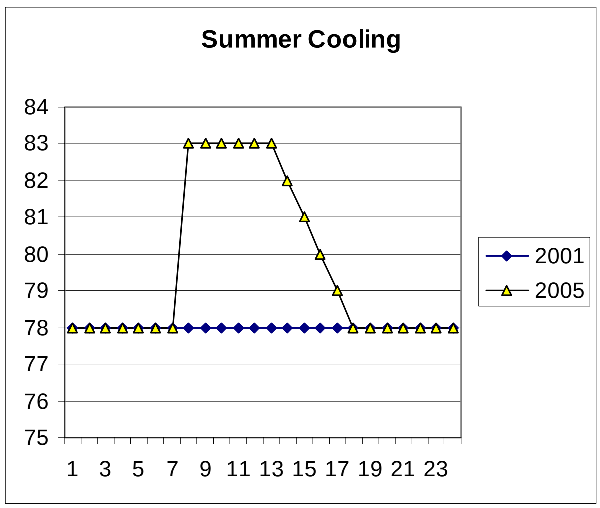

Figure 3 – Low-Rise Residential Cooling Thermostats

Prototype Approach

Methodology

The energy and electric demand impact of implementing the 2005 building envelope, HVAC, and water heating requirements is estimated through the use of two prototype buildings: one representing all single-family construction and one representing all multi-family construction. Each prototype building is made to minimally comply with the 2001 and the 2005 Standards. Heating, cooling, and water heating energy use is modeled using MICROPAS v6.54[8]. The analysis is completed for all 16 California climate zones, and the results are then weighted by the estimated number of housing starts in each zone.

Single-Family Prototype

The single-family prototype is the 1,761 ft^2 two-story, slab-on-grade prototype that was used to develop the 2001 and earlier standards. To keep the comparison equal, the 2001 energy simulations utilize the same software and modeling assumptions as the proposed 2005 Standards, which are described separately in this document. All measures in the analysis matches the 2001 and 2005 Standards prescriptive packages, including glazing distributed equally on each orientation. The prototypes were analyzed with a range of glazing areas and the results weighted by the number of starts in each glazing area range. The weights are based on the sites in the residential database (see Table 10).

Multi-Family Prototype

The multi-family estimates are based on a 9,016 ft^2, two-story slab-on-grade apartment building with 8 dwelling units. The analysis uses the same approach described for newly constructed single-family dwellings. Glazing is equally distributed by orientation and glazing area is varied by the distribution of glazing areas in the RER database that was developed previously under contract to the Commission through a survey of compliance documentation.

Glazing Area

For each prototype, a distribution of glazing areas ranging from 7% to 30% of the floor area was modeled and the results are weighted to arrive at statewide results. Table 10 shows the distribution of glazing area for single-family and multi-family buildings. For the 2001 results, the prescriptive package glazing (16% or 20% depending on climate) is used.

[8] This software was produced by EnerComp with the support of Southern California Edison and Pacific Gas and Electric Company and has been updated to include the modeling required by the proposed Residential ACM Manual including the proposed Time Dependent Valuation (TDV) changes.

Table 10 – Glazing Area Frequencies of Occurrence

Glazing Area (Percent of Floor Area)	Frequency of Occurrence	
	Single Family	Mulit-Family
7%	0.2%	0.7%
8%	0.0%	0.0%
9%	0.4%	5.0%
10%	1.5%	7.1%
11%	1.5%	7.1%
12%	3.7%	12.8%
13%	5.6%	12.1%
14%	8.6%	12.1%
15%	12.0%	7.1%
16%	12.7%	9.9%
17%	10.7%	5.7%
18%	10.1%	6.4%
19%	8.9%	3.5%
20%	7.1%	2.8%
21%	3.9%	3.5%
22%	3.5%	2.8%
23%	2.7%	0.7%
24%	2.5%	0.0%
25%	1.7%	0.0%
26%	1.3%	0.0%
27%	0.5%	0.0%
28%	0.2%	0.0%
29%	0.7%	0.0%
30%	0.0%	0.7%
	100.0%	**100.0%**

Source: Itron/Regional Economic Research surveys completed for California investor-owned utilities for single-family and the CEC for multi-family.

Water Heating

Table 11 shows the assumptions used to estimate savings. The water heating systems for both the single-family and multi-family prototypes are modeled in minimum compliance with the 2001 Standards and in minimum compliance with the 2005 Standards. The 2005 modeling assumptions and algorithms are used for both estimates to provide consistent results. Gas water heating is assumed in the analysis for both the 2001 and 2005 energy codes.

Table 11 – Water Heating Modeling Assumptions

Prototype	2001 Standard Design	2005 Standard Design
Single-Family	Each dwelling unit is assumed to have a single gas storage water heater with a tank capacity of 50 gallons and an EF of 0.525. A standard distribution system is assumed with no pipe insulation between the tank and the kitchen appliances.	Same as the 2001 standard design, except with an EF of 0.575. Pipes to the kitchen are assumed to be insulated, as required by the mandatory measures.
Multi-Family	Each dwelling unit is assumed to have its own 50-gallon storage water heater with an EF of 0.525.	With the prototype approach, 40% of multi-family dwelling units are assumed to be served by central systems in climate zones 6 through 10, and 15% in the other climate zones. For this portion of the population of newly constructed buildings, a central system is assumed in the Standard Design. See Section 3.7 of the Residential ACM Manual for details of the standard design system.

Analysis and Detailed Results

Table 12 and Table 13 show the first-year TDV savings by end use and climate zone for both the single-family and multi-family prototype buildings. This data is normalized on a per square foot basis for easy comparison. Space cooling savings are quite significant, accounting for an average kTDV/ft² reduction of 3.05 for single-family and 4.06for multi-family. Water heating is also significant, representing average kTDV/ft² reductions of 1.61 for single-family and 3.08 for multi-family. The data in these tables is weighted by the glazing area frequency of occurrences shown in Table 10. .

Table 14 and Table 15 show the first-year gas and electricity savings for each prototype building. This data is for the entire prototype building, and is not normalized on a per square foot basis as in Table 12 and Table 13. The multi-family data includes the entire 8-unit building. For single-family, the air conditioner improvements result in 216 kWh of savings per dwelling unit and coincident peak demand reduction of 920 W per dwelling unit. Average gas savings are 7 therms/year for space heating and 28 therms/year for water heating. For multi-family, the air conditioner improvements result in 189 kWh of savings per dwelling unit and coincident peak demand reduction of 820 W per dwelling unit. Average gas savings are 7 therms/year for space heating and 35 therms/year for water heating.

The space cooling demand savings are derived from ASHRAE design load calculations as modified to account for the peak impact of duct sealing, duct R-value, and radiant barriers. Air conditioner efficiency improvements are factored in at 1.33 kW/ton for the 10 SEER referenced in the 2001 Standards, and 1.14 kW/ton for the 12 SEER used in the proposed 2005 Standards.

Table 16 shows the estimated housing starts for both single-family and multi-family buildings. It is estimated that 108,468 newly constructed single-family homes and 41,732 multi-family homes will be constructed each year in California. This data is taken from the Construction Industries Research Board (CIRB). Construction activity is greatest in the Central Valley and other inland areas of the state. In climate zone 12 (Sacramento area) for instance, 24,671 newly constructed single-family homes are expected to be built each year. Another 15,172 are anticipated for climate zone 10, with 9,497 estimated for climate zone 13. Statewide energy savings projections are based on these anticipated housing starts.

Table 17 shows the overall first-year statewide savings for newly constructed residential buildings, which are calculated by combining the data from Table 16 with data from Table 14 and Table 15. Gas savings are estimated to be over 5.5 million therms, and electric savings are expected to be on the order of 34 GWh. Peak demand is expected to be reduced by 63.3 MW. Table 18 and Table 19 show the breakdown of the first-year statewide savings by building type (single-family and multi-family), climate zone, and end use. As in the 2001 Standards analysis, a diversity factor of 0.65 is applied to the cooling demand, with the energy and demand savings set to zero for the mild climates (1, 3, 5, 6 and 16) where air conditioning is rarely installed.

Table 12 – Single-Family First-Year TDV Savings by Climate Zone and End Use (kTDV/ft²)

This is based on the 1,761 ft^2 single-family prototype. When weighted by housing starts, the average TDV savings are 14.4 kTDV/ft², or a 20% reduction.

Climate Zone	Space Heating	Space Cooling	Water Heating	Total
1	0.27	-0.04	1.56	1.80
2	0.24	1.05	1.54	2.83
3	0.53	1.63	1.54	3.70
4	0.93	1.58	1.53	4.03
5	0.03	0.09	1.54	1.66
6	0.11	1.45	1.69	3.25
7	0.21	0.94	1.71	2.87
8	0.25	2.83	1.69	4.77
9	0.49	4.79	1.68	6.96
10	0.51	6.95	1.69	9.15
11	0.15	2.91	1.54	4.60
12	0.13	1.73	1.53	3.40
13	0.09	4.35	1.53	5.97
14	0.63	4.95	1.70	7.28
15	0.00	12.69	1.67	14.36
16	1.57	0.95	1.57	4.09
Average	0.38	3.05	1.61	5.04

Table 13 – Multi-Family First-Year TDV Savings by Climate Zone and End Use (kTDV/ft²)

This is based on the 9016 ft^2 8-unit multi-family prototype. When weighted by housing starts, the average TDV savings are 10.0 kTDV/ft², or a 20% reduction.

Climate Zone	**Space Heating**	**Space Cooling**	**Water Heating**	**Total**
1	0.27	0.04	2.58	2.89
2	0.56	1.85	2.61	5.02
3	0.70	2.27	2.61	5.58
4	1.29	1.94	2.63	5.85
5	0.20	0.95	2.61	3.77
6	0.29	2.07	3.85	6.21
7	0.36	1.09	3.91	5.36
8	0.45	3.35	3.89	7.69
9	0.66	5.52	3.92	10.10
10	0.60	7.90	3.92	12.42
11	0.62	4.42	2.66	7.69
12	0.52	3.07	2.64	6.24
13	0.42	6.01	2.69	9.12
14	0.81	6.62	2.97	10.40
15	0.09	14.92	3.23	18.24
16	1.62	2.89	2.57	7.08
Average	0.59	4.06	3.08	7.73

Table 14 – First-Year Electricity and Gas Savings for the Single-Family Prototype

Estimates are based on the 1,761 ft² single-family prototype building.

	Gas Savings (therms/y)			Space Cooling	
Climate Zone	**Space Heating**	**Water Heating**	**Total**	**Electricity Savings (kWh/y)**	**Electric Demand Savings (kW/y)**
1	5.08	28.88	31.87	-1.63	0.39
2	4.44	28.70	33.14	65.81	0.60
3	9.33	28.53	37.85	97.03	1.78
4	16.54	28.53	45.06	111.65	0.90
5	0.39	28.70	29.09	4.69	0.66
6	2.19	28.53	30.72	93.40	1.83
7	3.73	28.35	32.08	55.73	1.00
8	4.55	28.35	32.90	172.05	0.79
9	8.57	28.18	36.75	323.24	1.18
10	8.74	28.18	36.92	471.96	1.20
11	2.74	28.35	31.09	206.29	0.68
12	2.47	28.53	30.99	100.48	0.60
13	1.56	28.18	29.74	328.17	0.63
14	10.92	28.53	39.45	322.27	0.91
15	0.05	28.18	28.23	1031.09	0.87
16	28.45	29.06	57.51	66.85	0.73
Average	6.86	28.48	35.21	215.57	0.92

Table 15 – First-year Electricity and Gas Savings for the Multi-Family Prototype Building

Savings are based 9016 ft² 8-unit multi-family prototype. Savings are normalized for a single dwelling unit..

	Gas Savings (therms/y)			Space Cooling	
Climate Zone	**Space Heating**	**Water Heating**	**Total**	**Electricity Savings (kWh/y)**	**Electric Demand Savings (kW/y)**
1	2.99	30.85	33.83	0.98	0.49
2	6.47	31.26	37.73	81.33	0.56
3	7.84	31.26	39.10	86.53	1.50
4	14.64	31.44	46.08	91.93	0.76
5	2.40	31.27	33.68	37.87	0.76
6	3.33	41.86	45.19	87.07	1.55
7	4.00	42.10	46.11	41.58	0.83
8	5.19	42.19	47.38	132.14	0.67
9	7.38	42.35	49.74	242.22	0.93
10	6.67	42.40	49.07	349.37	0.93
11	6.90	31.67	38.57	211.38	0.62
12	5.94	31.47	37.42	130.22	0.56
13	4.79	32.16	36.94	308.26	0.58
14	9.09	31.89	40.98	290.63	0.78
15	0.99	34.66	35.66	802.24	0.75
16	18.48	30.56	49.05	134.02	0.84
Average	6.69	34.96	41.66	189.24	0.82

Table 16 – Estimated Housing Starts by Climate Zone

	Single-Family		Multi-Family	
Climate Zone	**Estimated Housing Starts**	**Percent (%)**	**Estimated Housing Starts**	**Percent (%)**
1	422	0.4%	89	0.2%
2	3,364	3.1%	1,344	3.2%
3	3,909	3.6%	3,758	9.0%
4	3,200	2.9%	4,596	11.0%
5	1,496	1.4%	412	1.0%
6	6,932	6.4%	7,978	19.1%
7	6,048	5.6%	3,967	9.5%
8	4,141	3.8%	1,890	4.5%
9	4,622	4.3%	2,575	6.2%
10	15,172	14.0%	4,763	11.4%
11	6,618	6.1%	1,220	2.9%
12	24,671	22.7%	5,154	12.4%
13	9,497	8.8%	686	1.6%
14	5,510	5.1%	629	1.5%
15	8,810	8.1%	1,793	4.3%
16	4,055	3.7%	880	2.1%
Total	**108,468**	**100.0%**	**41,732**	**100.0%**

Sources: Construction Industry Research Board (CIRB), existing house data from the California Department of Finance (DOF), and CONSOL.

Table 17 – Statewide First-Year Savings for Newly Constructed Residential Buildings

	Electricity (GWh)	Peak Demand (MW)	Natural Gas (millions therms)
Newly Constructed Single Family	28,103	49.4	3.7
Newly Constructed Multi-family	5,996	14.0	1.8
Total	34,099	63.3	5.5

Table 18 – Statewide Newly Constructed Single-Family First-Year Savings

Climate Zone	Electricity Savings (MWh)	Demand Reductions (MW)	Natural Gas (therms)
1			14,322
2	221	1.3	111,499
3			147,975
4	357	1.9	144,180
5			43,525
6			212,957
7	337	3.9	194,031
8	713	2.1	136,260
9	1,494	3.5	169,856
10	7,161	11.8	560,100
11	1,365	2.9	205,733
12	2,479	9.7	764,651
13	3,117	3.9	282,407
14	1,776	3.3	217,391
15	9,084	5.0	248,696
16			233,194
Total	28,103	49.4	3,686,777

Table 19 – Statewide Newly Constructed Multi-Family First-Year Savings

Climate Zone	Electricity Savings (MWh)	Demand Reductions (MW)	Natural Gas (therms)
1			3,001
2	109	0.5	50,703
3			146,908
4	422	2.3	211,783
5			13,859
6			360,523
7	165	2.1	182,906
8	250	0.8	89,532
9	624	1.5	128,069
10	1,664	2.9	233,698
11	258	0.5	47,072
12	671	1.9	192,848
13	211	0.3	25,344
14	183	0.3	25,781
15	1,438	0.9	63,919
16			43,138
Total	5,996	14.0	1,819,082

Database Approach

Methodology

An alternate estimate of statewide savings was produced using the database approach. A sample of 571 single-family and 151 multi-family dwellings was compiled from on-site surveys and/or compliance documentation from three different studies undertaken for investor-owned utilities and the CEC between 2000 and 2003. The location of the database sites are shown in Table 20.

The Residential New Construction (RNC) Interface developed by Itron/RER was used to generate the MICROPAS input files for this analysis. The RNC Interface uses data collected from on-site surveys or compliance documentation to create MICROPAS input files. The RNC Interface then passes the input file through MICROPAS, and produces standard design or custom budget results for both the 2001 and the 2005 standards. These data are produced for each site in the database.

The energy use is calculated for the site modeled in minimum compliance with the Standard Design for both the 2001 and the 2005 Standards. The savings for each site is the difference between the energy use for the 2001 and the 2005 Standard Designs. The savings are then averaged for the sites in each climate zone, weighted by the portion of the estimated housing starts in each climate zone that is represented by each building in the database.

Table 20 – Residential New Construction Database Sites by Building Type and Climate Zone

CEC Climate Zone	Single Family Homes	Multifamily Buildings
1	4	4
2	20	5
3	40	18
4	27	12
5	4	3
6	39	5
7	45	25
8	18	12
9	29	8
10	97	16
11	43	9
12	126	27
13	41	3
14	15	2
15	16	2
16	9	0
Total	573	151

Analysis and Detailed Results

Table 21 shows the estimated first-year energy savings attributable to the 2005 changes. Savings are computed for space heating, space cooling, and water heating. First-year gas savings are estimated to be about 7 million therms. First year electricity savings are estimated to be about 48 GWh. When compared to the prototype analysis using prototypes, this approach predicts about 20% more gas savings and 30% more electric savings per year for the same end uses.

The main reason that the database approach yields more savings is that the average single-family home in the database is 2,348 ft² which is about 33% larger than the 1,761 ft² prototype. Other reasons are shown below:

- A different approach was taken to estimate the impact of the new modeling rules for glass area. Statewide averages were used for the prototype approach (see Table 10), where with the database approach, each house was separately modeled.
- The volume-to-floor area ratios and the exterior surface-to-floor area ratios vary with each house in the prototype approach, while with the prototype approach, all estimates are based on a fairly compact building.
- The prototype approach uses a later version of MICROPAS.

Table 22 shows the average savings per home or dwelling unit. The average single-family home will save an estimated 370 kWh of electricity and 47 therms of gas in the first year in the first-year. The average multi-family dwelling unit will save 195 kWh of electricity and 38 therms of gas.

Table 23 shows the distribution of newly constructed single-family and multi-family homes expected to be built yearly. The total number is the same as that used in the prototype analysis, but, because of a different approach, the distribution is slightly varied.

Table 24 shows per home or per unit first-year savings expanded to estimate statewide savings by climate zone.

Table 21 – First-year Electricity and Natural Gas Savings for Newly Constructed Residential Buildings

	Electricity (GWh)	**Natural Gas (therms)**
Single Family	40.2	5,047,236
Multi-Family	7.9	1,751,762
Total	**48.0**	**6,798,998**

Table 22 – Average First-year Savings Per Unit/Home by CEC Climate Zone

	Single Family Homes		Multifamily Units	
Climate Zone	Electricity (kWh/home)	Natural Gas (therms/home)	Electricity (kWh/unit)	Natural Gas (therms/unit)
1	0	43	1	51
2	124	52	107	54
3	67	52	43	37
4	147	65	136	42
5	0	43	0	37
6	131	30	64	28
7	45	37	56	30
8	287	34	175	40
9	608	50	312	51
10	752	48	433	50
11	311	45	305	49
12	217	46	219	49
13	644	47	552	51
14	411	50	144	65
15	1,464	27	762	15
16	261	99	N/A	N/A
Average	*370*	*47*	*195*	*38*

Table 23 – Number of Newly Constructed Homes/Units

Note: The distribution of housing starts by climate zone differs from the estimates used with the prototype approach.

CEC Climate Zone	Single-Family Homes	Multi-Family Units
1	593	627
2	4,272	1,364
3	8,646	4,260
4	5,091	10,471
5	1,440	238
6	7,206	1,938
7	3,974	2,833
8	5,215	747
9	7,670	2,423
10	11,142	1,665
11	8,555	881
12	25,980	11,166
13	9,131	851
14	2,446	236
15	4,667	1,334
16	2,442	697
Statewide Total	108,468	41,732

Table 24 – Total First-Year Savings by CEC Climate Zone

	Single-Family		Multi-Family	
CEC Climate Zone	Electricity (kWh)	Natural Gas (therms)	Electricity (kWh)	Natural Gas (therms)
1	0	25,252	1	31,854
2	528	222,157	146	74,109
3	576	446,449	185	157,486
4	749	332,598	1,423	436,765
5	0	61,433	0	8,898
6	942	216,195	124	54,495
7	180	146,798	158	85,524
8	1,495	174,711	131	29,913
9	4,660	386,449	756	124,066
10	8,380	536,716	721	83,625
11	2,662	382,500	269	43,548
12	5,642	1,197,789	2,444	543,180
13	5,881	429,645	469	43,191
14	1,005	121,379	34	15,249
15	6,834	126,302	1,017	19,859
16	636	240,862	N/A	N/A
Total	40,169	5,047,236	7,878	1,751,762

Nonresidential

Standards Requirements

The following sections describe the significant changes to the nonresidential standards, organized by building envelope, HVAC, water heating and lighting.

Envelope

- ***Skylights*** §143(c) – The 2005 Standards require that at least 50% of the floor area be under skylights in low rise conditioned or unconditioned buildings with greater than 25,000 square feet of floor area, with ceiling heights greater than 15 ft, and with a lighting power density equal to or greater than 0.5 W/ft^2. Electric lighting in the daylit area must be controlled with multi-level automatic daylighting controls. Buildings in climate zones 1 and 16 are excepted, as are auditoriums, movie theaters, and museums.
- ***Cool Roofs*** §143(a)1. – With the 2005 standards, cool roofs are required for all low-slope roof applications. This means that the 2001 case is modeled with a solar reflectance of 30% and the 2005 case is modeled with a solar reflectance of 55%. The NRNC database assumes all roofs are "low pitch," hence, all are subject to the cool roof provisions.
- ***Fenestration*** §144(k) – The recommended window type is the same for both the 2001 and 2005 standards, but the NFRC procedures have been updated . The U-factors for both the 2001 and the 2005 cases are modeled with the updated NFRC ratings. This change is neutral, with regard to energy savings.
- ***Metal Building Roofs*** §143(a) – Metal building roofs are no longer allowed to use the R-value method, which makes the standard more stringent for this class of construction. The U-factors used for the 2001 and 2005 standards are shown in Table 25.

Table 25 – U-factor Requirements for Metal Roofs

	U-factor	
Climate Zone	2001 baseline	2005 baseline
6-9	U = 0.118	U = 0.054
all others	U = 0.108	U = 0.052

HVAC

- ***Duct Insulation and Duct Sealing*** §144(k) – This measure applies to buildings with more than 25% of the ducts outside of directly or indirectly conditioned space, Under the 2001 Standards, required duct insulation was R-4.2. For the 2005 Standards, required duct insulation is R-8. For the 2005 Standards ducts in this location must be tested and sealed to 8% total leakage. Under the 2001 Standards, ducts in this location are assumed to have 36% leakage.
- ***Equipment Efficiencies*** – The HVAC equipment EER, COP and efficiency values were updated based on Tables 112 A through G. For small equipment (less than 65,000 Btu/h), the new federal standards, adopted into the California Title 20 standards improve efficiency.
- ***Demand Control Ventilation (DCV)*** §121 – In the 2005 Standards, DCV is required for single-zone systems with an economizer (generally larger than 6.25 tons) which serve spaces with an occupant density greater than 40 ft^2 per person (except for classrooms). Required outside air quantities for bars and cocktail lounges were reduced from 1.5 to 0.2 CFM/sq. ft.
- ***Other Measures (§144)***

- o §144(c)2. B. Variable speed drives are required on all VAV fan motors greater than or equal to 10 hp (used to be 25 hp with the 2001 standards).
- o §144(c)4. Electronically commutated motors (ECM) are required for series fan powered terminal units.
- o §144(h)3. All cooling towers with multiple condenser pumps to 33% of design flow must be run in parallel.
- o §144(h)4. Cooling towers serving loads 300 tons and greater must use propeller fans not centrifugal fans.
- o §144(i). Chiller plants over 300 tons must limit air cooled chillers to 100 tons or less; the remainder of the capacity must be provided through water-cooled equipment.
- o §144(j)1. Chilled water distribution systems with 3 or fewer AHUs and/or fan coils are required to have CV pumping with water temperature reset control.
- o §144(j)1. Systems with 3 or more AHUs and/or fan coils must have variable hot water pumping with constant water temperature, variable speed chilled water pumping with constant water temperature, and variable speed pumps on water loop heat pumps (WLHP).
- o §144(j)4 Chilled and hot water systems with a design capacity exceeding 500,000 Btu/hr are required to have temperature reset controls.
- o §144(j)5 Water loop heat pump systems with pump systems with a design capacity exceeding 5 hp are required to have specific variable speed controls.
- o §144(j)6 Individual pumps must meet specific variable speed control requirements.

Note that savings for requirements in §144(c) 2 C for static pressure sensor location, §144(c)2D for set point reset, §144(j)2 and §144(j)3 for chiller and boiler isolation were not estimated.

Water Heating

- ***Small Water Heaters***. The Title 20 Appliance Efficiency Standards increase the efficiency improvements for small gas and electric storage water heaters (see Table 26)

Table 26 – Minimum Energy Factor for Title 20 Water Heater Efficiency Improvements for Small Water Heaters

See CEC Appliance Efficiency Standards, Table F-5 – Standards for Small Federally-Regulated Water Heaters

		Minimum Energy Factor (EF)	
Type	Size	Effective Date April 15, 1991	Effective Date January 20, 2004
Gas Storage	< 75,000 Btu/hr	0.62-(0.0019*V)	0.67-(0.0019*V)
Gas Instantaneous	<200,000 Btu/hr	0.62-(0.0019*V)	0.62-(0.0019*V)
Oil Storage	<105,000 Btu/hr	0.59-(0.0019*V)	0.59-(0.0019*V)
Oil Instantaneous	<210,000 Btu/hr	0.59-(0.0019*V)	0.59-(0.0019*V)
Electric Storage (exc. Table top)	< 12KW	0.93-(0.00132*V)	0.97-(0.00132*V)
Electric Table Top	< 12KW	0.93-(0.00132*V)	0.93-(0.00132*V)
Electric Instantaneous (exc. table top)	< 12KW	0.93-(0.00132*V)	0.93-(0.00132*V)
Note: V refers to tank volume (gal).			

Lighting

- ***Lighting Power Density*** §146 – Allowed lighting power densities have been lowered for many spaces. Savings are calculated by applying the area category method to each space type identified in the NRNC database. The space types in Table 27 will be affected by this change:

Table 27 – Changes to Nonresidential Lighting Power Requirements

	Allowed Lighting Power (W/ft²)	
Space Type	2001	2005
Auditorium	2.0	1.5
Auto repair	1.2	1.1
Classrooms	1.6	1.2
Convention, conference, etc.	1.5	1.4
General C&I work – high bay	1.2	1.1
Hotel function	2.2	1.5
Kitchen, food prep	1.7	1.6
Hotel lobby	1.7	1.1
Medical and clinical care	1.4	1.2
Office	1.3	1.2
Precision C&I work	1.5	1.3
Religious worship	2.1	1.5
Retail merchandise sales, wholesale showrooms	2.0	1.7

Methodology

Each building in the Nonresidential New Construction (NRNC) database was simulated with the 2001 and 2005 requirements using DOE-2. For each building in the database, the requirements applicable to that building and its systems and equipment from both the 2001 and 2005 Standards was simulated. The difference between these cases is the impact of the standard. The database consists of 985 sites distributed in all 16 climate zones, representing the principal nonresidential building occupancy types. Table 28 summarizes the sites in the database by climate and building type.

The Title 24 modeling assumptions in the ACM were followed for all the runs, except that the schedules that were reported from the surveys for each building were used to estimate the savings rather than the standard schedules specified in the nonresidential ACM.

Table 28 – Nonresidential New Construction Database Sites by Occupancy Type and Climate Zone

	Climate Zone																
Building Type	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
Colleges, Universities		1	8	6		4	1	3	7	1	1	2	2	3			39
Elem/Scndry Schools		5	13	7	2	12	4	8	12	18	7	22	33	15	4	1	163
Food Stores	1	1	7	8	2	3		2	2	2	3	7	5		2		45
Hospitals *		1	6			2		1	1			9	1			1	22
Hotel/Motel		2	1			2	1					1			1		8
Large Office		3	17	9		8	3	6		6	1	5					58
Large Retail	1	3	7	5		8	2	8	10	11		6	1	2	1		65
Medical Clinic *		2	6	2	2	4	1	4	1		3	1	4		1		31
Misc.	3	10	42	11	5	17	7	22	32	17	11	28	12	11	7	2	237
Non-Refrg Whses		2	9			2		2	2		3	12	9	1			42
Restaurants	1		5	3	2	5		2	3	6		1	4	3	1		36
Small Office		1	25	23	2	17	14	11	7	5	7	14	6	6			138
Small Retail		3	10	13	4	8	8	6	9	8	1	18	3	5	4		100
Grand Total	6	34	156	87	19	92	41	75	86	74	37	126	80	46	21	4	984

* Not included in the analysis of the Standards since these building types are outside the scope of the Standards.

Water Cooled Chillers

Section 144(i) requires all chiller plants over 300 tons to limit air cooled chillers to 100 tons or less. The DOE-2 modeling strategy reads the total chiller plant capacity and if the capacity is greater than 300 tons (3.6 MMBtu/hr) then:

- Read each chiller in building; sort by condenser type (cchiller.condtype) and capacity (cchiller.cchsize). Change condenser type from air to water until sum of air cooled chiller capacity less than 100 tons.
- Add a cooling tower of sufficient capacity to meet the loads of all the water cooled chillers.

Chilled Water Flow Control

Section 144(j) has flow control requirements for chilled water and hot water circulation systems. The DOE-2 modeling strategies are as follows:

For all chilled distribution systems with three or fewer AHUs and/or fan coils:

- 2001 baseline: As surveyed condition
- 2005 baseline: CV pumping with water temperature reset control

For all chilled or hot water distribution systems with more than 3 AHUs and/or fan coils

- 2001 baseline: As surveyed condition
- 2005 baseline: Variable flow hot water pumping with constant water temperature, variable speed chilled water pumping with constant water temperature. Variable speed pumps on WLHPs.

Cooling Tower Fans

Section 144(h)4. addresses fan power in cooling towers. The purpose is to limit the use of centrifugal fans, which have a higher power requirement per cfm (or gpm of cooling water) than propeller type fans. The fan hp assumptions for each fan type, normalized per gpm of condenser water are:

- Minimum of 38.2 gpm/hp for prop fans

- Minimum of 20 gpm/hp for centrifugal fans

For towers smaller than 300 tons, 60% are assumed to have centrifugal fans and for towers larger than 300 tons, 40% are assumed to have centrifugal fans.[9] The tower fan power is adjusted according these data and the following DOE-2 commands and keywords were used for the 2001 and the 2005 cases.

Run	DOE-2 Command	DOE-2 Keyword/value
2001 baseline	HEAT-REJECTION	CELL-CTRL = MIN-CELLS MIN-FLOW/CELL = 0.33 If cTower.RateCap ≤ 4,500 ELECTRIC-INPUT-RATIO = 0.0206 If cTower.RateCap > 4,500 or not defined, ELECTRIC-INPUT-RATIO = 0.0182
2005 baseline	HEAT-REJECTION	CELL-CTRL = MAX-CELLS MIN-FLOW/CELL = 0.33 ELECTRIC-INPUT-RATIO = 0.0133

Variable Floor Condenser Loop

Section 144(h)3. specifies the control strategy for cooling towers with multiple condenser pumps. The baseline (2001) strategy assumes that each tower will be run to full capacity before bringing on the next tower. The 2005 code requires that all towers be run in parallel down to 33% of design flow; as the load decreases, then towers turn down in sequence.

Note: The NRNC database does not have information about cooling tower control strategies. This analysis assumes all towers will be run using the strategies indicated.

VAV VSD Fan Requirement

Section 144(c)2. of the standard requires variable speed drives on all VAV fans greater or equal to 10 hp. This measure is modeled as follows:

Run	DOE-2 Command	DOE-2 Keyword/value
2001 baseline	SYSTEM	SUPPLY-FAN-CONTROL Set to INLET if fan type is VAV and fan hp ≤ 25 Else set to SPEED
2005 baseline	SYSTEM	SUPPLY-FAN-CONTROL Set to INLET if fan type is VAV and fan hp < 10 Else set to SPEED

ECM Motors

The average fan power per cfm for standard series fan powered boxes is 0.45 W/cfm[10]. Substituting ECM motors reduces the specific fan power by approximately 50%. The DOE-2 modeling strategy is as follows:

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9 Based on personal communication with Mark Hydeman at Taylor Engineering.

10 ECM motors for Series Fan Powered Boxes. From Measure Analysis and LCC Pt. IV, Prepared by Eley Associates and Taylor Engineering, August, 2002.

If zonal HVAC system type is series fan powered VAV box, then

Run	DOE-2 Command	DOE-2 Keyword/value
2001 baseline	ZONE	ZONE-FAN-KW/FLOW = 0.00045 kW/cfm
2005 baseline	ZONE	ZONE-FAN-KW/FLOW = 0.000225 kW/cfm

Skylights

The approach was to identify all spaces with a baseline LPD greater than 0.5 W/ft², a floor area greater than 25,000 ft², and a ceiling height greater than 15 ft. The procedure below is followed for such spaces:

- Add skylights to 50% of the space @ 3.6% of roof area for spaces with baseline LPD ≥ 1 W/ft².
- Add skylights to 50% of the space @ 3.0% of roof area for spaces with baseline LPD between 0.5 and 1 W/ft².
- Use stepped lighting controls in the skylit space (area fraction = 0.5)
- Exclude auditoriums, movie theaters, and museums
- Exclude buildings in climate zones 1 and 16
- For spaces with skylights larger than required by the Standards, do not change.
- For spaces with skylights less than required by the Standards, increase to Standard.
- For spaces with daylighting controls area fraction less than standard, increase to Standard.

Demand Control Ventilation (DCV)

For the 2001 standard, spaces listed in Table 29 are assumed to have DCV. These spaces are assumed to have an occupancy greater than 10 persons per 1,000 ft² (less than 10 ft²/person). Table 29 and Table 30 show the modeling assumptions for the 2001 and 2005 cases, respectively. :

Table 29 – Spaces with DCV Required by the 2001 Standards

Code	Occupancy	Minimum Area (ft²)	Minimum Ventilation Rate (cfm/ft²)
1	Auditorium	2,800	0.15
2	Churches/Chapels	2,800	0.15
6	Main Entry Lobby	2,800	0.15
7	Motion Picture Theater	2,800	0.15
8	Performance theater	2,800	0.15

Table 30 – Spaces with DCV Required by the 2005 Standards

Code	Occupancy	Minimum Area (ft^2)	Minimum Ventilation Rate (cfm/ft^2)
1	Auditorium	n. a.	.15
2	Churches/Chapels	n. a.	.15
3	Conventions, conference, meeting centers	n. a.	.15
4	Courtrooms	n. a.	.15
5	Exhibit	n. a.	.15
6	Main Entry Lobby	n. a.	.15
7	Motion Picture Theater	n. a.	.15
8	Performance theater	n. a.	.15
9	Bars, cocktail lounges, casinos	n. a.	.20
10	Dining	n. a.	.15
26	Hotel Function	n. a.	.15
30	Bowling alley	n. a.	.15
33	Grocery	n. a.	.15
34	Malls, Arcades, Atria	n. a.	.15
35	Retail sales, wholesale showrooms	n. a.	.20
42	School shops	n. a.	.15
43	Swimming pools	n. a.	.15

For DOE-2 modeling of DCV, outside air is scheduled to follow the space occupancy schedule data collected during the on-site survey. Hourly outdoor air quantities will be calculated using the hourly occupancy of the space applied to the minimum OA per ft^2, assuming full occupancy.

Duct Efficiency

ASHRAE 152 calculations detailed in the non-residential ACM Appendix NG are used to estimate the benefits of duct sealing and insulation. The duct efficiency assumptions by climate zone are listed in Table 31 and Table 32 below for newly constructed buildings. Since DOE-2 does not have a duct model, these efficiency values are used to modify the efficiency of the equipment on an annual basis.

Table 31 – Seasonal Duct Efficiency Assumptions for 2001 Baseline

Climate zone	Heating Seasonal Duct Zone Temp	Cooling Seasonal Duct Zone Temp	Heating Seasonal Efficiency	Cooling Seasonal Efficiency
CTZ01	47.3	81.4	0.769	0.816
CTZ02	41.8	97.1	0.761	0.665
CTZ03	47.8	86.6	0.770	0.765
CTZ04	43.9	92.0	0.764	0.714
CTZ05	46.2	86.0	0.768	0.772
CTZ06	50.8	87.3	0.775	0.759
CTZ07	49.3	88.7	0.772	0.746
CTZ08	47.3	93.1	0.769	0.703
CTZ09	48.7	94.4	0.771	0.690
CTZ10	45.7	98.2	0.767	0.654
CTZ11	43.9	98.4	0.764	0.652
CTZ12	44.2	97.3	0.764	0.662
CTZ13	43.3	103.6	0.763	0.601
CTZ14	37.2	102.7	0.754	0.611
CTZ15	47.2	104.3	0.769	0.595
CTZ16	37.9	96.3	0.755	0.672
Calculations assume 36% total leakage; R-4.2 duct insulation, standard (non-cool) roof				

Table 32 – Seasonal Duct Efficiency Assumptions for 2005 Baseline

Climate zone	Heating Seasonal Duct Zone Temp	Cooling Seasonal Duct Zone Temp	Heating Seasonal Efficiency	Cooling Seasonal Efficiency
CTZ01	47.3	75.3	0.914	0.954
CTZ02	41.8	88.2	0.911	0.907
CTZ03	47.8	79.8	0.914	0.937
CTZ04	43.9	84.5	0.912	0.920
CTZ05	46.2	79.3	0.913	0.939
CTZ06	50.8	81.1	0.916	0.933
CTZ07	49.3	82.3	0.915	0.928
CTZ08	47.3	85.9	0.914	0.915
CTZ09	48.7	87.2	0.915	0.911
CTZ10	45.7	90.0	0.913	0.900
CTZ11	43.9	90.5	0.912	0.898
CTZ12	44.2	89.3	0.912	0.903
CTZ13	43.3	94.9	0.912	0.883
CTZ14	37.2	93.8	0.909	0.887
CTZ15	47.2	97.1	0.914	0.875
CTZ16	37.9	87.5	0.909	0.909
Calculations assume 8% total leakage; R-8 duct insulation, cool roof				

Buildings likely to have ductwork in an unconditioned space were chosen from the NRNC database to represent the type and size of buildings observed in the NBI PIER study and the Statewide BEA NRNC study.[11]

[11] Pacific Gas and Electric Company, "Nonresidential Duct Sealing and Insulation," Codes and Standards Enhancement Initiative Final Report, May 2003.

Overall, 15% of the small packaged systems observed in these studies have ductwork in unconditioned space. The breakdown of building types observed to have ductwork in unconditioned space is shown in Table 33.

Table 33 – Building Types with Ductwork in Unconditioned Space

Building type	Percent of Buildings with Ducts Outside the Conditioned Space
Church	0.69%
Grocery	0.84%
Gym	0.07%
Light Manufacturing	6.76%
Office	5.98%
Restaurant	0.12%
School	0.61%
Single-story large retail	6.66%
Unconditioned warehouse	78.27%

Note, most of the buildings having ductwork in unconditioned space were warehouses containing conditioned office space, where the ductwork was run from the roof through the unconditioned warehouse to the conditioned office. Buildings meeting this description were randomly selected from the NRNC database such that the total building area affected by the duct efficiency calculations was 15% of the total, and the distribution of the building types matched the distribution above.

Hourly duct efficiencies were calculated from the seasonal efficiencies modified on an hourly basis using the methodology described in the NACM Appendix NG. The hourly electric and gas was calculated from:

$$kW_{cool,rev} = \frac{kW_{cool,sim}}{\eta_{cool}}$$

$$kW_{heat,rev} = \frac{kW_{heat,sim}}{\eta_{heat}}$$

$$therm_{heat,rev} = \frac{therm_{heat,sim}}{\eta_{heat}}$$

where

η_{heat} and η_{cool} is just the duct efficiency, not the system or equipment efficiency.

These calculations are performed in the post processing step. The efficiency is adjusted hourly with (t). Based on calculations in nonresidential ACM Appendix NG.

Analysis and Detailed Results

Table 34 – Nonresidential Statewide First-Year Savings

Climate Zone	Electricity (GWh)	Non-Coincident Demand (MW)	Coincident Demand (MW)	Gas (therms)	TDV (MBtu)
1	0.55	0.11	0.13	10,967	10,842
2	8.33	2.93	3.13	241,638	175,119
3	19.11	6.97	6.17	93,950	344,545
4	8.77	3.56	2.72	22,103	166,928
5	1.69	0.61	0.54	28,046	32,209
6	7.83	2.20	2.11	-45,860	136,849
7	12.01	1.72	2.48	-50,059	149,765
8	10.48	4.14	2.22	-44,649	200,522
9	14.96	5.73	5.12	-30,894	305,415
10	16.34	6.68	5.07	105,937	343,468
11	2.31	2.59	1.26	-27,418	37,620
12	15.97	6.75	5.85	233,758	313,431
13	10.51	5.18	3.71	28,567	195,112
14	6.20	2.70	1.67	-8,529	108,819
15	4.65	2.67	1.31	70,659	97,599
16	0.85	0.58	0.36	62,222	21,694
Total	140.59	55.13	43.87	690,438	2,639,937

Table 35 – Nonresidential Projected Construction Activity by Climate Zone

The distribution of construction activity among the California climate zones is based on the surveyed sites in the NRNC database.

	Representative City	Floor Area (ft²)	Percent of Total Floor Area
1	Arcata	492,900	0%
2	Santa Rosa	11,145,900	7%
3	Oakland	25,217,400	16%
4	Sunnyvale	11,336,700	7%
5	Santa Maria	2,973,300	2%
6	Los Angeles	9,571,800	6%
7	San Diego	11,861,400	7%
8	El Toro	13,928,400	9%
9	Pasadena	16,472,400	10%
10	Riverside	13,403,700	8%
11	Red Bluff	2,226,000	1%
12	Sacramento	23,055,000	15%
13	Fresno	9,476,400	6%
14	China Lake	3,816,000	2%
15	El Centro	3,148,200	2%
16	Mount Shasta	874,500	1%
Total		159,000,000	100%

Table 36 – Nonresidential First-Year Energy and Demand Savings

Climate Zone	Electricity (kWh/ft²)	Non-Coincident Demand (W/ft²)	Coincident Demand (W/ft²)	Gas (Btu/ft²)[12]	TDV (kBtu/ft²)
1	1.12	0.22	0.27	0.02	22.00
2	0.75	0.26	0.28	0.02	15.71
3	0.76	0.28	0.24	0.00	13.66
4	0.77	0.31	0.24	0.00	14.72
5	0.57	0.20	0.18	0.01	10.83
6	0.82	0.23	0.22	0.00	14.30
7	1.01	0.15	0.21	0.00	12.63
8	0.75	0.30	0.16	0.00	14.40
9	0.91	0.35	0.31	0.00	18.54
10	1.22	0.50	0.38	0.01	25.62
11	1.04	1.16	0.57	-0.01	16.90
12	0.69	0.29	0.25	0.01	13.59
13	1.11	0.55	0.39	0.00	20.59
14	1.63	0.71	0.44	0.00	28.52
15	1.48	0.85	0.42	0.02	31.00
16	0.98	0.67	0.41	0.07	24.81
Total	0.90	0.35	0.28	0.00	16.76

Table 37 – Nonresidential Anticipated Energy and Demand Growth with 2001 Standard

Climate Zone	Electricity (kWh/ft²)	Non-Coincident Demand (W/ft²)	Coincident Demand (W/ft²)	Gas (Btu/ft²)	TDV (kBtu/ft²)
1	30.13	5.27	4.32	0.56	596.74
2	17.80	4.69	4.17	0.26	347.65
3	19.41	4.83	3.93	0.27	374.35
4	23.70	6.16	4.90	0.47	475.42
5	19.52	4.64	3.79	2.33	605.86
6	18.73	4.50	3.60	0.30	406.98
7	20.76	5.46	4.62	0.25	406.13
8	19.46	5.25	3.84	0.20	413.59
9	18.78	5.69	4.36	0.35	419.14
10	27.10	8.69	6.06	0.32	590.25
11	27.99	8.77	5.69	0.57	552.31
12	17.88	4.92	4.04	0.28	349.51
13	14.33	5.47	3.57	0.23	283.87
14	20.37	6.38	3.47	0.42	453.63
15	30.01	9.25	6.65	0.34	636.26
16	24.01	8.59	3.82	0.42	463.24
Weighted Average	20.30	5.70	4.36	0.32	419

[12] The Standards affect gas use in both directions. For example, adding skylights, cool roofs, and reduced lighting power density increase gas use. Duct sealing, improved insulation in metal roofs, and demand controlled ventilation save gas. The net result of these changes is either plus or minus, depending on the mix of building types in the database.

Table 38 – Nonresidential Anticipated Energy and Demand Growth with 2005 Standard

Climate Zone	Electricity (kWh/ft²)	Non-Coincident Demand (W/ft²)	Coincident Demand (W/ft²)	Gas (Btu/ft²)	TDV (kBtu/ft²)
1	29.01	5.05	4.05	0.54	574.75
2	17.06	4.42	3.89	0.24	331.94
3	18.66	4.55	3.69	0.27	360.69
4	22.92	5.85	4.66	0.47	460.70
5	18.95	4.44	3.61	2.32	595.03
6	17.92	4.27	3.38	0.30	392.69
7	19.75	5.31	4.41	0.25	393.50
8	18.70	4.95	3.68	0.21	399.19
9	17.87	5.35	4.05	0.35	400.60
10	25.88	8.19	5.68	0.31	564.63
11	26.95	7.60	5.13	0.59	535.41
12	17.18	4.63	3.79	0.27	335.92
13	13.22	4.93	3.18	0.23	263.28
14	18.75	5.67	3.03	0.42	425.12
15	28.54	8.40	6.24	0.32	605.25
16	23.03	7.93	3.41	0.35	438.44
Weighted Average	19.40	5.35	4.08	0.31	402

Table 39 – Nonresidential First-Year Electricity Savings by End Use

	kWh/ft²			GWh		
End Use	2001 Standard	2005 Standard	Savings	2001 Standard	2005 Standard	Savings
Heating	0.24	0.23	0.01	39	37	2
Cooling	3.38	3.15	0.23	537	502	36
Lighting	5.42	4.89	0.53	862	778	84
Fans	2.67	2.54	0.13	425	404	21
Refrigeration	1.70	1.70	0.00	270	270	0
Equipment	6.88	6.88	0.00	1,095	1,095	0
Total	20.30	19.40	0.90	3,227	3,084	143

Table 40 – Nonresidential First-Year Demand Savings by End Use

	Wh/ft²			MW		
End Use	2001 Standard	2005 Standard	Savings	2001 Standard	2005 Standard	Savings
Heating	0.02	0.02	0.00	3.6	3.5	0.1
Cooling	1.74	1.59	0.15	276.7	253.1	23.6
Lighting	0.99	0.90	0.10	157.9	142.6	15.3
Fans	0.50	0.47	0.03	79.7	74.6	5.0
Refrigeration	0.20	0.20	0.00	32.4	32.4	0.0
Total (NC)	5.70	5.35	0.35	906.5	851.0	55.5
Total (C)	4.36	4.08	0.28	692.5	648.5	44.0

Note: NC = non-coincident, C = coincident

Table 41 – Nonresidential First-Year Gas Savings by End Use

	KBtu/ft²			Therms		
End Use	2001 Standard	2005 Standard	Savings	2001 Standard	2005 Standard	Savings
Heating	9,625	9,328	297	15,304,244	14,831,499	472,745
Cooling	202	181	21	320,945	287,673	33,273
Total	31,597	31,269	328	50,238,733	49,717,530	521,203

Relocatable Classrooms

The 2005 standard adds requirements for relocatable classrooms that apply statewide. Unit energy savings from the relocatable classroom CASE initiative[13] are used to estimate statewide savings. The assumed common practice and 2005 code requirements are shown in Table 42. The proposed standard will result in an average of 1, 043 kWh/y for each relocatable classroom. Unit savings are shown in Table 43, which are calculated for a typical 24 ft by 40 ft relocatable classroom in five climate zones. Based on an estimate of 3,000 relocatable classrooms being constructed each year, Table 44 shows the estimated statewide impact of 3.1 GWh. There are no gas savings associated with relocatable classrooms since all are assumed to be conditioned with an electric heat pump.

Table 42 – Summary of 2005 Requirements for Relocatable Classrooms

	Assumed Common Practice	2005 Code requirements
Wall insulation	R-11 (no insulation on beams)	R-13 (including steel beams)
Floor Insulation	R-11	R-19
Ceiling Insulation	R-19	R-30
Glass type	2 pane standard	2 pane low e glass
Lighting Power density	1.71 W/ft²	1.2 W/ft²
Heat pump efficiency	10 SEER	12 SEER

Table 43 – Relocatable Classroom First-Year Unit Energy Savings.

Climate zone	Common Practice electricity consumption (kWh)	2005 Code compliant energy consumption (kWh)	Savings (kWh per unit)
4	11,514	10,548	966
6	10,079	9,317	762
12	12,481	11,427	1,054
14	13,740	12,393	1,347
16	14,854	13,770	1,084
Average			1,043

Table 44 – Relocatable Classroom First-Year Statewide Impact

	Common Practice electricity consumption (GWh)	2005 Code compliant energy consumption (GWh)	Savings (GWh per unit)
	37.6	34.5	3.1

13 High Performance Relocatable Classrooms, CASE Initiative Report, Pacific Gas and Electric Company, June, 2002.

Outdoor Lighting

Standards Requirements

Outdoor lighting has not previously been regulated, but with Senate Bill 5X, the CEC was given responsibility and authority to develop standards for outdoor lighting applications. These standards are contained in Section §147 and §148 of the proposed 2005 Standards. Standards are proposed for the following lighting applications. The estimates are based on the June 11, 2003 internal draft, which is substantially similar to the February 4, 2003 workshop draft. Any changes made to the standards following this draft are not reflected in the estimates.

- Hardscape including parking lots
- Driveways, site roads, sidewalks, walkways and bikeways
- Building entrances (without canopy)
- Outdoor sales areas
- Building façades
- Outdoor sales frontage (in linear feet)
- Vehicle service station canopies
- All other sales canopies
- Non-sales canopies
- Landscape and ornamental lighting
- Internally illuminated panel signs
- Externally illuminated signs

Methodology

Estimates of outdoor lighting energy savings and demand reductions were calculated by RLW Analytics as part of the CEC PIER outdoor lighting project. The report is titled "*Statewide Impact of the California 2005 Energy Efficiency Standards for Commercial Outdoor Lighting",* March 18, 2003 and is included as Appendix B of this document. To calculate the estimate, the proposed standards are applied to the California Outdoor Lighting Baseline Assessment database and model, which establishes the use of commercial outdoor lighting in California.[14]

Results from the RLW report are adjusted in this section for internally and externally illuminated signs. The basis of these adjustments are described below.

- The standard for internally illuminated signs has changed from 11 W/ft² to 12 W/ft² since the original report was developed. The 12 W/ft² requirement can be satisfied by substituting an electronic ballast in a conventional sign.
- The assessment study determined a baseline of 20 W/ft² for internally illuminated signs, while CEC conversations with the sign industry indicate that common practice for new signs is 16 W/ft².
- The CEC expects that the standard for new externally illuminated signs will reduce the power for each lamp from 400 W to 320 W. This change can be achieved by changing from a probe start metal halide lamp to a pulse start type.

[14] This report was completed by RLW Analytic, Inc on November 8, 2002 and submitted to the New Buildings Institute (NBI) on contractor to the California Energy Commission Public Interest Energy Research (PIER) Program. It can be downloaded from the NBI website: www.newbuildings.org.

The effect of the above items is to reduce the savings for signs, relative to the original estimates by RLW. The tables in this section include the adjustment, while the RLW document contains the unadjusted estimate.[15] Estimates of electricity savings have changed from 41% to 25% for internally illuminated signs and from 65% to 22% for externally illuminated signs.

Analysis and Detailed Results

Table 45 summarizes the outdoor lighting electricity savings related to the Standards. Without the Standards, electricity consumption for outdoor lighting is expected to increase by 68,250 MWh each year. With implementation of the proposed Standards, this growth is reduced to 51,101 MWh, with annual savings of 17,149 MWh. These savings are for the first year, and will accumulate in each year thereafter, doubling in year two, tripling in year three, etc. Peak demand savings are not estimated for the outdoor lighting standards since the peak generally occurs during August or September late afternoon hours. The Standards will impact the amount of outdoor lighting that is on at this time. The California winter peak that occurs after dark in the winter can cause serious electricity system problems. Rolling blackouts occurred at this time in January 2001. At the winter peak the new outdoor lighting requirements are expected to save 6.3 MW.

Table 46 shows electricity savings broken out by lighting zones, and

Table 47 presents the savings broken out by California climate zone[16].

[15] Ibid.

[16] Outdoor lighting is assumed to match nonresidential construction with regard to where it is constructed in California.

Table 45 – Statewide Outdoor First-Year Lighting Electricity Savings by Lighting Application (MWh)

	Baseline	2005 Standard	Savings	Percent Reduction
Parking Lots and Hardscape	30,854	25,549	5,305	17.2%
Pathways (Driveways, Sidewalks, etc)	13,570	6,043	7,526	55.5%
Building Entrances (without canopy)	501	243	258	51.6%
Outdoor Sales Area	2,813	2,810	4	0.1%
Building Façades	1,185	762	423	35.7%
Outdoor Sales Frontage	260	237	23	8.8%
Vehicle Service Station Canopies	493	271	222	45.0%
All Other Sales Canopies	52	51	1	2.1%
Non-sales canopies	5,935	5,396	539	9.1%
Landscape and Ornamental Lighting	1,044	926	118	11.3%
Internally Illuminated Panel Signs	6,331	4,748	1,583	25.0%
Externally Illuminated Signs	5,211	4,065	1,146	22.0%
Totals	**68,250**	**51,101**	**17,149**	**25.1%**

Table 46 – Statewide Outdoor Lighting First-Year Electricity Savings by Lighting Application and Lighting Zone (MWh)

	LZ1	**LZ2**	**LZ3**	**LZ4**	**Total**
Parking Lots and Hardscape	130	830	4,328	17	5,305
Pathways (Driveways, Sidewalks, etc.)	105	267	7,087	67	7,526
Building Entrances (without canopy)	3	36	217	2	258
Outdoor Sales Area	2	2	0	0	4
Building Façades	12	27	381	3	423
Outdoor Sales Frontage	3	5	15	0	23
Vehicle Service Station Canopies	3	19	199	1	222
All Other Sales Canopies	1	1	0	0	1
Non-sales canopies	28	136	372	3	539
Landscape and Ornamental Lighting	10	0	107	0	118
Internally Illuminated Panel Signs	38	65	1,462	17	1,583
Externally Illuminated Signs	15	46	1,073	13	1,146
Totals	**350**	**1,432**	**15,242**	**124**	**17,149**

Table 47 – Statewide Outdoor Lighting First-Year Electricity Savings by Climate Zone (MWh)

Climate Zone	Representative City	Percent of Construction	Electricity Savings (MWh)
1	Arcata	0%	53
2	Santa Rosa	7%	1,202
3	Oakland	16%	2,720
4	Sunnyvale	7%	1,223
5	Santa Maria	2%	321
6	Los Angeles	6%	1,032
7	San Diego	7%	1,279
8	El Toro	9%	1,502
9	Pasadena	10%	1,777
10	Riverside	8%	1,446
11	Red Bluff	1%	240
12	Sacramento	15%	2,487
13	Fresno	6%	1,022
14	China Lake	2%	412
15	El Centro	2%	340
16	Mount Shasta	1%	94
Totals		**100%**	**17,149**

Alterations to Existing Buildings

Residential Fenestration

Under the proposed Standards, replacement fenestration will be required to meet the prescriptive package requirements. Savings estimates for fenestration alterations are based on the methodology described in the “Windows Efficiency Requirements Upon Window Replacement” report from the April 22, 2002 CEC workshop.

The first-year savings for each dwelling unit are shown in Table 48. These are combined with estimated replacements shown in

Table 49 to produce the first-year statewide estimates shown in Table 50. For fenestration replacement, 25,000 homes are estimated to be affected by the Standards change each year.

Table 48 –Fenestration Replacement Savings Per Dwelling Unit

	Fenestration Replacement		
Climate Zone	Electricity (kWh)	Peak Demand (kW)	Natural Gas (therms)
1	7	0.0	19
2	257	0.2	21
3	68	0.0	11
4	186	0.1	13
5	98	0.1	14
6	146	0.1	6
7	159	0.1	5
8	241	0.1	7
9	350	0.2	8
10	428	0.3	11
11	438	0.3	19
12	347	0.2	17
13	506	0.3	15
14	525	0.3	20
15	1,090	0.6	6
16	155	0.1	46
Average	*313*	*0.2*	*15*

Table 49 – Distribution of Existing Housing Stock by Climate Zone

Climate Zone	Existing Housing Stock	Percent
1	31,534	0.6%
2	157,073	2.8%
3	847,835	15.3%
4	344,260	6.2%
5	55,982	1.0%
6	675,254	12.2%
7	283,992	5.1%
8	604,711	10.9%
9	530,214	9.6%
10	334,815	6.0%
11	244,995	4.4%
12	687,033	12.4%
13	285,954	5.2%
14	194,918	3.5%
15	172,171	3.1%
16	89,447	1.6%
Total	**5,540,189**	**100.0%**

Table 50 –Fenestration Replacement First-Year Statewide Savings

	Fenestration Replacement		
Climate Zone	**Electricity (MWh)**	**Peak Demand (MW)**	**Natural Gas (therms)**
1			2,768
2	182	0.1	14,668
3			42,256
4	289	0.1	20,650
5			3,583
6			17,004
7	204	0.1	7,003
8	657	0.3	19,035
9	838	0.3	18,637
10	647	0.2	16,277
11	484	0.2	21,379
12	1,077	0.4	52,985
13	653	0.2	18,753
14	462	0.2	17,384
15	847	0.3	4,727
16			18,536
Total	**6,340**	**2.4**	**295,646**
Percent	15%	9%	10%

Residential Duct Sealing

Standards Requirements

In climate zones 2 and 9 through 16:

- Duct systems must be tested and sealed[17] at the time that an air conditioner, heat pump, or furnace is replaced or installed in an existing building.
- New or replacement duct systems in existing buildings shall have an insulation level that is the same as the prescriptive requirements for newly constructed buildings, and be tested and sealed[18].

The proposed requirements are triggered either by installation of a furnace, an indoor-air heat-exchanger coil, an outdoor condensing unit for a heat pump or air conditioner, or by installation of a new or replacement duct system in an existing structure. The analysis did not include an estimate of savings for duct insulation and duct sealing when ducts are replaced or new ducts are installed.

Methodology

Duct sealing alteration estimates are derived from a series of MICROPAS runs on the 1,761 ft^2 single-family home using the building envelope and efficiency values typical before the California Energy Standards became effective in 1978. This analysis is described in the “Duct Sealing Requirements Upon HVAC or Duct-System Replacement” report from the May 30, 2002 CEC workshop.

Analysis and Detailed Results

Table 51 shows the projection of statewide first-year savings by measure and by climate zone. For duct sealing, 50,000 homes are affected by the Standards change in climate zones 2 and 9-16.

17 Options available for sealing are: 1) seal total leakage to 15% of fan flow; 2) seal leakage to outside to 10% of fan flow, 3) reduce the pre-existing leakage by 60%. If one of these criteria can not be achieved, all accessible leaks can be sealed and verified by a visual inspection and smoke test by a certified HERS rater.

18 If the new ducts are added to an existing duct system, the sealing options above apply. If the new ducts form an entirely new duct system directly connected to the air handler, the ducts must be sealed to 6% of fan flow.

Table 51 –Duct Sealing in Alterations First-Year Statewide Savings

	Duct Sealing		
Climate Zone	**Electricity (MWh)**	**Peak Demand (MW)**	**Natural Gas (therms)**
1			
2	759	1.1	213,603
3			
4			
5			
6			
7			
8			
9	3,715	4.4	216,432
10	3,657	2.9	185,789
11	3,399	2.5	321,120
12	6,070	5.9	798,714
13	4,684	2.9	276,618
14	3,955	2.1	310,149
15	8,903	2.4	49,553
16			347,453
Total	35,142	24.3	2,719,430
Percent	84.7%	91.0%	90.2%

Nonresidential Interior Lighting

New lighting systems in existing buildings and modifications to existing lighting systems that affect more than 50% of the luminaries must meet the mandatory control requirements and lighting power requirements of §146. The way the standards apply to alterations to existing buildings does not change between 2001 and 2005, but the standards are more stringent. The impact on new lighting systems in existing buildings is the difference between the 2001 and the 2005 standards, which is an average first-year energy savings of 0.53 kWh/ft² and a demand reduction of 0.10 W/ft². This is the weighted average of the 984 buildings in the NRNC database (see the analysis of nonresidential newly constructed buildings).

The CEC estimates that the nonresidential building stock in California is 5.7 billion ft².[19] If we assume that the lighting systems in these buildings are replaced every twenty years, then about 285 million ft² of nonresidential newly constructed buildings would be affected each year. This results in 150.7 GWh of statewide first-year electricity savings and 27.4 MW of statewide first-year demand reduction. The estimate is summarized in Table 52.

[19] Martha Brook, California Energy Commission, PIER Indoor Environmental Quality Request for Proposals, December 2002.

Table 52 – First-year Impact of Lighting Standard for Alterations to Existing Buildings

	2001 Standard	2005 Standard	Savings	Percent Reduction
Annual Energy (kWh/ft²-y)	5.42	4.89	0.53	9.8%
Peak Demand (W/ft²)	0.99	0.90	0.10	9.7%
Annual Energy (GWh)	1,544.5	1,393.8	150.7	9.8%
Peak Demand (MW)	283.0	255.6	27.4	9.7%
Assumptions				
Existing Stock	5,700,340,000	ft²	CEC estimate	
Churn Rate	5	% per year	Lighting systems replaced every 20 years	
Stock Affected Each Year	285,017,000	ft²	Existing Stock times Churn Rate	

Nonresidential Duct Sealing

Duct Sealing §149(b)1.E. The 2005 standards require that ducts be sealed when air handlers, cooling coils or furnace heat exchangers are replaced in existing buildings where greater than 30% of the duct surface area is outside of conditioned space. The Standards also require that the ducts be sealed and duct insulation be increased to R-8 when ducts are replaced or new ducts are installed. For the 2001 standards 36% total leakage and R-4.2 duct insulation is assumed. For the 2005 standards, 15% total leakage and R-8 duct insulation is assumed. ASHRAE 152 calculations detailed in the non-residential ACM Appendix NG are applied to a sample of buildings in the NRNC database.

The duct efficiency assumptions and efficiencies by climate zone are listed in. Table 53. Calculations for 2001 standards assume 36% total leakage; R-4.2 duct insulation, standard (non-cool) roof, while calculations for 2005 standards assume 17% total leakage; R-8 duct insulation, standard (non-cool) roof.

Existing building stock and end-use intensity (EUI) data were obtained from the CEC.[20] The fraction of the floor space served by equipment addressed by the Standards by building type was estimated from the NRNC database. This is summarized in Table 54. The efficiency improvement was projected across the existing building population, subject to the modifiers shown in Table 55.[21] The energy savings calculations are summarized in Table 56 and the demand reduction calculations are summarized in Table 57.

[20] California Energy Demand, 2000-2010, Publication # 200-00-002. July 14, 2000.

[21] Duct Sealing Requirements Upon HVAC or Duct System Replacement: Existing Buildings. CASE Initiative Report. Pacific Gas and Electric Company, July 2002.

Table 53 – Alterations to Existing Nonresidential Building – Seasonal Duct Efficiency Assumptions

Climate zone	Heating Seasonal Duct Zone Temp	Cooling Seasonal Duct Zone Temp	2001 Heating Seasonal Efficiency	2001 Cooling Seasonal Efficiency	2005 Heating Seasonal Efficiency	2005 Cooling Seasonal Efficiency	Heating Savings	Cooling Savings
1	47.3	81.4	0.769	0.816	0.862	0.888	10.7%	8.1%
2	41.8	97.1	0.761	0.665	0.858	0.802	11.4%	17.1%
3	47.8	86.6	0.770	0.765	0.862	0.859	10.7%	10.9%
4	43.9	92.0	0.764	0.714	0.859	0.830	11.1%	14.0%
5	46.2	86.0	0.768	0.772	0.861	0.863	10.8%	10.6%
6	50.8	87.3	0.775	0.759	0.864	0.856	10.3%	11.3%
7	49.3	88.7	0.772	0.746	0.863	0.848	10.5%	12.1%
8	47.3	93.1	0.769	0.703	0.862	0.824	10.7%	14.7%
9	48.7	94.4	0.771	0.690	0.862	0.817	10.6%	15.5%
10	45.7	98.2	0.767	0.654	0.861	0.796	10.9%	17.9%
11	43.9	98.4	0.764	0.652	0.859	0.795	11.1%	18.0%
12	44.2	97.3	0.764	0.662	0.860	0.801	11.1%	17.3%
13	43.3	103.6	0.763	0.601	0.859	0.766	11.2%	21.5%
14	37.2	102.7	0.754	0.611	0.855	0.772	11.9%	20.9%
15	47.2	104.3	0.769	0.595	0.861	0.763	10.7%	22.0%
16	37.9	96.3	0.755	0.672	0.856	0.807	11.8%	16.6%
Average							11.0%	15.5%

Table 54 – Fraction of Existing Building Floor Space with Equipment Affected by the Duct Sealing Provision

Building Type	Fraction of Existing Building Floor Space Served by Equipment Covered by Duct Sealing Provision
Large Offices	0.119
Small Offices	0.322
Restaurants	0.652
Retail	0.328
Food Stores	0.198
Warehouses	0.071
Schools	0.574
Colleges	0.037
Hospital/ Healthcare	0.118
Hotels/ Motels	0.135
Miscellaneous	0.330

Table 55 – Service Life for HVAC Equipment – Nonresidential Duct Replacements

Assumption	Value
System service life	20 yr
Fraction of systems with ducts outside conditioned space (existing buildings)	0.625
Fraction of systems that have leakage above 15% test threshold	0.85

Table 56 – First-Year Energy Savings from Duct Sealing in Alterations to Existing Nonresidential Buildings

Commercial Occupancy Types	Floor Area (million ft²)	Floor space affected (million ft²)	Cooling (kWh/sf-yr)	Heating (kWh/sf-yr)	Total Cooling Consumption of affected systems (GWh)	Total Cooling Savings (GWh)	Total Heating Consumption of affected systems (GWh)	Total Heating Savings (GWh)	Total Energy Savings (GWh)	Total TDV (kBtu)
Large Offices	1,024.28	3.238	4.17	0.45	13.83	2.14	1.46	0.16	2.30	43,621,808
Small Offices	361.03	3.091	2.52	0.17	2.81	0.44	0.53	0.06	0.49	9,762,568
Restaurants	145.17	2.516	4.42	0.45	1.61	0.25	1.13	0.12	0.37	8,837,690
Retail	882.35	7.687	1.4	0.1	9.50	1.47	0.77	0.08	1.56	29,044,692
Food Stores	230.52	1.211	2.54	0.33	0.71	0.11	0.40	0.04	0.15	3,500,718
Warehouses	787.43	1.494	0.35	0.13	0.41	0.06	0.19	0.02	0.09	1,886,110
Schools	457.47	6.977	0.74	0.24	2.36	0.37	1.67	0.18	0.55	13,001,053
Colleges	270.13	0.263	2.35	0.79	0.17	0.03	0.21	0.02	0.05	1,266,517
Hospital/ Healthcare	278.57	0.872	8.53	0.73	2.07	0.32	0.64	0.07	0.39	8,166,247
Hotels/ Motels	270.87	0.971	2.35	1.97	0.62	0.10	1.91	0.21	0.31	9,144,576
Miscellaneous	992.52	8.694	2.37	0.31	20.45	3.17	2.70	0.30	3.47	66,598,769
Total	5,700.34	37.015	2.5	0.39	54.54	8.45	14.44	1.28	9.73	172,236,965

Table 57 – First-Year Demand Savings from Duct Sealing in Alterations to Existing Buildings

Commercial Occupancy Types	Floor Area (Millions SF)	Floor space affected (mSF)	Cooling (W/sf)	Total Cooling Demand of affected systems (MW)	Total Cooling Demand Savings (MW)
Large Offices	1,024.28	3.238	2.75	8.905	1.38
Small Offices	361.03	3.091	1.66	5.132	0.80
Restaurants	145.17	2.516	1.59	4.000	0.62
Retail	882.35	7.687	0.74	5.688	0.88
Food Stores	230.52	1.211	0.95	1.150	0.18
Warehouses	787.43	1.494	0.18	0.269	0.04
Schools	457.47	6.977	0.61	4.256	0.66
Colleges	270.13	0.263	1.47	0.386	0.06
Hospital/ Healthcare	278.57	0.872	4.86	4.239	0.66
Hotels/ Motels	270.87	0.971	1.66	1.612	0.25
Miscellaneous	992.52	8.694	1.36	11.823	1.83
Total	5,700.34	37.015	1.49	55.152	7.36

Table 58 – First-Year Gas Savings from Duct Sealing in Alterations to Existing Buildings

Commercial Occupancy Types	Floor Area (Millions SF)	Floor space affected (mSF)	Heating (kBtu/SF)	Total Heating Consumption of affected systems (kTherm)	Gas Savings (kTherm)	Total TDV kBtu
Large Offices	1,024.28	3.238	22.42	726	80	8,225,958
Small Offices	361.03	3.091	22.42	693	76	7,852,661
Restaurants	145.17	2.516	16.36	412	45	4,663,527
Retail	882.35	7.687	18.74	1,441	158	16,321,357
Food Stores	230.52	1.211	21.73	263	29	2,980,843
Warehouses	787.43	1.494	26.67	398	44	4,514,890
Schools	457.47	6.977	26.16	1,825	201	20,680,490
Colleges	270.13	0.263	19.31	51	6	575,136
Hospital/ Healthcare	278.57	0.872	60.48	528	58	5,977,341
Hotels/ Motels	270.87	0.971	20.36	198	22	2,239,927
Miscellaneous	992.52	8.694	33.08	2,876	316	32,583,585
Total	5,700.34	37.015		9,410	1,035	106,615,716

Nonresidential Cool Roofs

When low-slope roofs are replaced, §149(b)1.B. of the proposed standard requires that they be a cool roof with an initial reflectance of at least 70% and an emittance greater than 75%. The savings related to this requirement were estimated as part of the PG&E case initiative. These are summarized in Table 59. For each 1,000 ft² of roof area (10 squares) that is cool roof as opposed to a standard roof, electric energy would be reduced by 327 kWh and demand would be reduced by 0.21 W. Gas use would be increased by an average of 4.5 therms. These figures apply only for buildings that are air conditioned.

The nonresidential building stock in California is estimated to be 5.7 billion ft² of floor area. From the NRNC database, the roof area to floor area is estimated to be 80% so the roof area of existing buildings is estimated to be about 4.6 billion ft². From the PG&E case initiative report, about 80% of new roofs being installed (prior to the new Standards) are not a cool roof, as defined by the Standards. Since the benefits of cool roofs only occur for conditioned spaces, the PG&E research estimates that 46% of nonresidential building affected by the standard are conditioned during the day. In addition, not all roof replacements obtain a building permit and some roof replacements would be excepted from the cool roof requirement. The exception is for the case when the existin roof has a rock or gravel surface because of a The standard has an exception for existing roofs with a rock or gravel surface (see §149(b)1.B. for details). It is assumed that 50% of roof replacements would either quality for this exception or not obtain a building permit. The final assumption, also taken from the PG&E case initiative, is that roofs are replaced every 15 years. When the above assumptions are combined, it is estimated that each year the standard would cause about 45 million ft² of roof to be a cool roof, that would otherwise not be a cool roof. Using the average unit energy and demand saving factors, this results in 14.6 GWh of first-year electricity savings, 9.5 MW of first-year demand reduction, however, first-year gas use would increase by about 200,000 therms. See Table 60 for details of the calculations.

Table 59 – Cool Roofs Unit Energy and Demand by Climate Zone

Climate Zone	Fraction of Total ft²	Required Roof R-value	kWh/ 1,000 ft²	Therms/ 1,000 ft²	kW/ 1,000 ft²
1	0.31%	19	117	-8.8	0.15
2	7.01%	19	319	-6.1	0.22
3	15.87%	19	196	-4.8	0.17
4	7.13%	19	256	-4.5	0.19
5	1.87%	19	198	-4.8	0.18
6	6.02%	11	412	-4.1	0.25
7	7.46%	11	331	-2.6	0.27
8	8.76%	11	438	-3.9	0.27
9	10.36%	11	426	-4.5	0.22
10	8.43%	19	366	-3.7	0.19
11	1.40%	19	287	-5	0.17
12	14.50%	19	302	-5.3	0.21
13	5.96%	19	375	-5.3	0.21
14	2.40%	19	374	-4.6	0.23
15	1.98%	19	409	-1.8	0.18
16	0.55%	19	246	-10.7	0.2
Minimum			117	-10.7	0.15
Maximum			438	-1.8	0.27
Average			316	-5	0.21
Weighted Average			327	-4.5	0.21

Table 60 – Cool Roofs First-year Savings Calculations

Assumptions		
Existing building stock	5,700,340,000	ft²
Frequency of Roof Replacement	15	years
Percent low-slope application	80%	
Percent exempted built-up roof	50%	
Market penetration of non-cool roof products.	80%	%
Ratio of roof area to floor area	80%	%
Ratio of daytime conditioned SF to total SF	46%	%
Total cool roof replacement market	44,751,469	ft²/year
Unit Energy and Demand Savings		
Unit Electricity Savings	327	kWh/1,000 ft²
Unit Demand Savings	0.21	kW/1,000 ft²
Unit Gas Impact	-4.5	therms/1000 ft²
Statewide Impact		
Electricity Savings	14.6	GWh
Demand Savings	9.5	MW
Gas Impact	-203,465	therms

Other Nonresidential Measures in Alterations to Existing Buildings

The analysis did not include estimates for savings in alterations due to the other nonresidential requirements summarized on pages 29 and 30.

Appendix A – Nonresidential On-Site Survey and Modeling Procedure

This appendix provides information on the nonresidential new construction (NRNC) database. This database includes 990 buildings The study was conducted by RLW Analytics and Architectural Energy Corporation on behalf of the California Board for Energy Efficiency (CBEE) under the management of Southern California Edison Company. This study was intended to give CBEE and future program administrators and implementers some of the information they need to alter the long-term behavior of the actors in the NRNC market and to assess the impact of their programs. Specifically, the study contributed information needed to:

- Understand current design and building practice,
- Understand the attitudes and motivations of market actors, and
- Have a baseline against which to measure success of efforts to change both attitudes and design practice.

Two primary sources were used to develop the information presented in this study:

- Qualitative and quantitative surveys of the designers of newly constructed buildings–architects and engineers, and
- Onsite audits and DOE-2 simulations of the physical and energy attributes of the buildings themselves.

On-Site Surveys

The primary data source for the nonresidential DOE-2 models used to assess impact was the on-site survey. The survey form was designed so that key modeling decisions on model zoning and equipment/space association were made by the surveyors in the field. The form was designed to follow the logical progression of an on-site survey process. The form started out with a series of interview questions. Conducting the interview first helped orient the surveyor to the building and allowed time for the surveyor to establish a rapport with the customer. Once the interview was completed, an inventory of building equipment was conducted. The survey started with the HVAC systems, and progressed from the roof and/or other mechanical spaces into the conditioned spaces. This progression allowed the surveyor to establish the linkages between the HVAC equipment and the spaces served by the equipment. The incented measures were identified during the on-site audit.

Interview Questions

The surveyor used the interview questions to identify building characteristics and operating parameters that were not observable during the course of the on-site survey. The interview questions covered the following topics:

Building functional areas. Functional areas were defined on the basis of operating schedules. Subsequent questions regarding occupancy, lighting, and equipment schedules, were repeated for each functional area.

Occupancy history. The occupancy history questions were used to establish the vacancy rate of the building during 1998. The questions covered occupancy, as a percent of total surveyed floor space, and HVAC operation during the tenant finish and occupancy of the space. Responses to these questions were used to understand building start-up behavior during the model calibration process.

Building Occupancy schedules. For each functional area in the building, a set of questions were asked to establish the building occupancy schedules. First, the surveyor assigned each day of the week to one of three daytypes: full occupancy, partial occupancy, and unoccupied. This was done to cover buildings that did not operate on a normal Monday through Friday workweek. Holidays and monthly variability in occupancy schedules were identified.

Daily schedules for occupants, interior lighting, and equipment/plug loads. A set of questions was used to establish hourly occupancy, interior lighting, and miscellaneous equipment and plug load schedules for each functional area in the building. During the on-site survey, the surveyor defined hourly schedules for each daytype. A value, which represents the fraction of the maximum occupancy and/or connected load was entered for each hour of the day. The entry of the schedule onto the form was done graphically.

Daily schedules of kitchen equipment. A set of questions were asked to establish hourly kitchen equipment schedules for each functional area in the building for each daytype. A value which represented the equipment-operating mode (off, idle, or low, medium or high volume production) was entered for each hour of the day. The entry of the schedule onto the form was done graphically.

Operation of other miscellaneous systems. General questions on the operation of exterior lighting systems, interior lighting controls, window shading, swimming pools, and spas were covered in this section.

Operation of the HVAC systems. A series of questions were asked to construct operating schedules for the HVAC systems serving each area. The surveyors entered fan operating schedules and heating and cooling setpoints. A series of questions were used to define the HVAC system controls. These questions were intended to be answered by someone familiar with the operation of the building mechanical systems. The questions covered operation of the outdoor air ventilation system, supply air temperature controls, VAV system terminal box type, chiller and chilled water temperature controls, cooling tower controls, and water-side economizers.

Building-wide water use. A series of questions were used to help calculate the service hot water requirements for the building.

Refrigeration system. The operation of refrigeration systems utilizing remote condensers, which are common in groceries and restaurants, was covered in this section. Surveyors divided the systems into three temperature classes, (low, medium and high) depending on the compressor suction temperature. For each system temperature, the refrigerant, and predominant defrost mechanism was identified. Overall system controls strategies were also covered.

Building Characteristics

The next sections of the on-site survey covered observations on building equipment inventories and other physical characteristics. Observable information on HVAC systems, building shell, lighting, plug loads, and other building characteristics were entered, as described below:

Built-up HVAC systems. Make, model number, and other nameplate data were collected on the chillers, cooling towers, heating systems, air handlers, and pumps in the building. Air distribution system type, outdoor air controls, and fan volume controls were also identified.

Packaged HVAC systems. Equipment type, make, model number, and other nameplate data were collected on the packaged HVAC systems in the building.

Zones. Based on an understanding of the building layout and the HVAC equipment inventory, basic zoning decisions were made by the surveyors according to the following criteria:

- ***Unusual internal gain conditions***. Spaces with unusual internal gain conditions, such as computer rooms, kitchens, laboratories were defined as separate zones.
- ***Operating schedules***. Occupant behavior varies within spaces of nominally equivalent use. For example, retail establishments in a strip retail store may have different operating hours. Office tenants may also have different office hours.
- ***HVAC system type and zoning***. When the HVAC systems serving a particular space were different, the surveyors sub-divided the spaces according to HVAC system type. If the space was zoned by exposure, the space was surveyed as a single zone, and a “zone by exposure” option was selected on the survey form.

For each zone defined, the surveyor recorded the floor area and occupancy type. Enclosing surfaces were surveyed, in terms of surface area, construction type code, orientation, and observed insulation levels. Window areas were surveyed by orientation. The surveyor also identified and inventoried basic window properties, interior and exterior shading devices, lighting fixtures and controls, and miscellaneous equipment and plug loads. Finally, the surveyor identified and entered zone-level HVAC equipment, such as baseboard heaters, fan coils, and VAV terminals.

Refrigeration systems. The surveyor inventoried the refrigeration equipment separately, and associated the equipment with a particular zone in the building. Refrigerated cases and stand-alone refrigerators were identified by case type, size, product stored, and manufacturer. Remote compressor systems were inventoried by make, model number, and compressor system type. Each compressor or compressor rack was associated with a refrigerated case temperature loop and heat rejection equipment such as a remote condenser, cooling tower, and/or HVAC system air handler. Remote condensers were inventoried by make, model number, and type. Nameplate data on fan and pump hp were recorded. Observations on condenser fan speed controls were also recorded.

Cooking Equipment. The surveyor recorded the cooking equipment separately and associated with a particular zone in the building. Major equipment was inventoried by equipment type (broiler, fryer, oven, and so on), size, and fuel type. Kitchen ventilation hoods were inventoried by type and size. Nameplate data on exhaust flowrate and fan hp were recorded and each piece of kitchen equipment was associated with a particular ventilation hood.

Hot Water/Pools. Water heating equipment was inventoried by system type, capacity, and fuel type. The surveyor recorded observations on delivery temperature, heat recovery, and circulation pump horsepower. Solar water heating equipment was inventoried by system type, collector area, and collector tilt and storage capacity. The surveyor inventoried pools and spas by surface area and location (indoor or outdoor). The filter pump motor horsepower was recorded, along with the surface area, collector type, and collector tilt angle data for solar equipment serving pools and/or spas.

Miscellaneous exterior loads. Connected load, capacity, and other descriptive data on elevators, escalators, interior transformers, exterior lighting, and other miscellaneous equipment were recorded.

Meter Numbers. Additional data were collected in the field to assist in the billing data account matching and model calibration process. This section served as the primary link between the on-site survey and billing data for non-participants. The surveyor recorded meter numbers for each meter serving the surveyed space. If the meter served space in addition to the surveyed space, the surveyor made a judgment on the ratio of the surveyed space to the space served by the meter.

Establishing Component Relationships

In order to create a DOE-2 model of the building from the various information sources contained in the on-site survey, relationships between the information contained in the various parts of the survey needed to be established. In the interview portion of the form, schedule and operations data were cataloged by building functional area. In the equipment inventory section, individual pieces of HVAC equipment: boilers, chillers, air handlers, pumps, packaged equipment and so on were inventoried. In the zone section of the survey, building envelope data, lighting and plug load data, and zone-level HVAC data were collected. The following forms provided the information needed by the software to associate the schedule, equipment, and zone information.

System/Zone Association Checklist. The system/zone association checklist provided a link between each building zone and the HVAC equipment serving that zone. Systems were defined in terms of a collection of packaged equipment, air handlers, chillers, towers, heating systems, and pumps. Each system was assigned to the appropriate thermal zones in accordance with the observed building design.

Interview "Area" / Audit "Zone" Association Checklist. Schedule and operations data gathered during the interview phase of the survey were linked to the appropriate building zone. These data were gathered according to the building functional areas defined previously. Each building functional area could contain multiple zones. This table facilitated the association of the functional areas to the zones, and thereby the assignment of the appropriate schedule to each zone.

Modeling Procedures

An automated process was used to develop basic DOE-2 models from data contained in the on-site surveys, Title 24 compliance forms, program information and other engineering data. The modeling software took information from these data sources and created a DOE-2 model. The data elements used, default assumptions, and engineering calculations are described for the Loads, Systems, and Plant portions of the DOE-2 input file as follows.

Loads

Schedules were created for each zone in the model by associating the zones defined in the on-site survey with the appropriate functional area, and assigning the schedule defined for each functional area to the appropriate zone. Hourly schedules were created by the software on a zone-by-zone basis for:

- Occupancy
- Lighting
- Electric equipment
- Gas equipment (primarily kitchen equipment)
- Solar glare
- Window shading
- Infiltration

Occupancy, lighting, and equipment schedules. Each day of the week was assigned to a particular daytype, as reported by the surveyor. Hourly values for each day of the week were extracted from the on-site database according to the appropriate daytype. These values were modified on a monthly basis, according to the monthly building occupancy history.

Solar and shading schedules. The use of blinds by the occupants was simulated by the use of solar and shading schedules. The glass shading coefficient values were modified to account for the use of interior shading devices.

Infiltration schedule. The infiltration schedule was established from the fan system schedule. Infiltration was scheduled “off” during fan system operation, and was scheduled “on” when the fan system was off.

Shell materials. A single-layer, homogeneous material was described which contains the conductance and heat capacity properties of the composite wall used in the building. The thermal conductance and heat capacity of each wall and roof assembly was taken from the Title 24 documents, when available. If the Title 24 documents were not available, default values for the conductance and heat capacity were assigned from the wall and roof types specified in the on-site survey, and the observed R-values. If the R-values were not observed during the on-site survey and the Title 24 documents were not available, an “energy-neutral” approach was taken by assigning the same U-value and heat capacity for the as-built and Title 24 simulation runs.

Windows. Window thermal and optical properties from the building drawings or Title 24 documents (when available) were used to develop the DOE-2 inputs. If these documents were not available, default values for the glass conductance were assigned according to the glass type specified in the on-site survey. If the glass type was not observed during the on-site survey and the Title 24 documents were not available, an “energy-neutral” approach was taken by assigning the same U-value and shading coefficient for the as-built and Title 24 simulation runs.

Lighting kW. Installed lighting power was calculated from the lighting fixture inventory reported on the survey. A standard fixture wattage was assigned to each fixture type identified by the surveyors. Lighting fixtures were identified by lamp type, number of lamps per fixture, and ballast type as appropriate.

Lighting controls. The presence of lighting controls was identified in the on-site survey. For occupancy sensor and lumen maintenance controls, the impact of these controls on lighting consumption was simulated as a reduction in connected load, according to the Title 24 lighting control credits. Daylighting controls were simulated using the “functions” utility in the load portion of DOE-2. Since the interior walls of the zones were not surveyed, it was not possible to use the standard DOE-2 algorithms for simulating the daylighting illuminance in the space. A daylight factor, defined as the ratio of the interior illuminance at the daylighting control point to the global horizontal illuminance was estimated for each zone subject to daylighting control. Typical values for sidelighting applications were used as default values. The daylight factor was entered into the function portion of the DOE-2 input file. Standard DOE-2 inputs for daylighting control specifications were used to simulate the impacts of daylighting controls on lighting schedules. The default daylight factors were adjusted during model calibration.

Equipment kW. Connected loads for equipment located in the conditioned space, including miscellaneous equipment and plug loads, kitchen equipment and refrigeration systems with integral condensers were calculated. Input data were based on the “nameplate” or total connected load. The nameplate data were adjusted using a “rated-load factor,” which is the ratio of the average operating load to the nameplate load during the definition of the equipment schedules. This adjusted value represented the hourly running load of all equipment surveyed. Equipment diversity was also accounted for in the schedule definition.

For the miscellaneous equipment and plug loads, equipment counts and connected loads were taken from the on-site survey. When the connected loads were not observed, default values based on equipment type were used.

For the kitchen equipment, equipment counts and connected loads were taken from the on-site survey. Where the connected loads were not observed, default values based on equipment type and “trade size” were used. Unlike the miscellaneous plug load schedules, the kitchen equipment schedules were defined by operating regime. An hourly value corresponding to “off”, “idle”, or “low,” “medium,” or “high” production rates were assigned by the surveyor. The hourly schedule was developed from the reported hourly operating status and the ratio of the hourly average running load to the connected load for each of the operating regimes.

For the refrigeration equipment, refrigerator type, count, and size were taken from the on-site survey. Equipment observed to have an “integral” compressor/condenser that is, equipment that rejects heat to the conditioned space, were assigned a connected load per unit size.

Source input energy. Source input energy represented all non-electric equipment in the conditioned space. In the model, the source type was set to natural gas, and a total input energy was specified in terms of Btu/hr. Sources of internal heat gains to the space that were not electrically powered include kitchen equipment, dryers, and other miscellaneous process loads. The input rating of the equipment was entered by the surveyors. As with the electrical equipment, the ratio of the rated input energy to the actual hourly consumption was calculated by the rated load factor assigned by equipment type and operating regime.

Heat gains to space. The heat gains to space were calculated based on the actual running loads and an assessment of the proportion of the input energy that contributed to sensible and latent heat gains. This in turn depended on whether or not the equipment was located under a ventilation hood.

Spaces. Each space in the DOE-2 model corresponded to a zone defined in the on-site survey. In the instance where the “zoned by exposure” option was selected by the surveyor, additional DOE-2 zones were created. The space conditions parameters developed on a zone by zone basis were included in the description of each space. Enclosing surfaces, as defined by the on-site surveyors, were also defined.

Systems

This section describes the methodology used to develop DOE-2 input for the systems simulation. Principal data sources include the on-site survey, Title 24 documents, manufacturers’ data, and other engineering references as listed in this section.

Fan schedules. Each day of the week was assigned to a particular daytype, as reported by the surveyor. The fan system on and off times from the on-site survey was assigned to a schedule according to daytype. These values were modified on a monthly basis, according to the monthly HVAC operating hour adjustment. The on and off times were adjusted equally until the required adjustment percentage was achieved. For example, if the original schedule was “on” at 6:00 hours and “off” at 18:00 hours, and the monthly HVAC adjustment indicated that HVAC operated at 50% of normal in June, then the operating hours were reduced by 50% by moving the “on” time up to 9:00 hours and the “off” time back to 15:00 hours.

Setback schedules. Similarly, thermostat setback schedules were created based on the responses to the on-site survey. Each day of the week was assigned to a particular daytype. The thermostat setpoints for heating and cooling, and the setback temperatures and times were defined according to the responses. The return from setback and go to setback time was modified on a monthly basis in the same manner as the fan-operating schedule.

Exterior lighting schedule. The exterior lighting schedule was developed from the responses to the on-site survey. If the exterior lighting was controlled by a time clock, the schedule was used as entered by the surveyor. If the exterior lighting was controlled by a photocell, a schedule, which follows the annual variation in daylength, was used.

System type. The HVAC system type was defined from the system description from the on-site survey. The following DOE-2 system types were employed:

- Packaged single zone (PSZ)
- Packaged VAV (PVAVS)
- Packaged terminal air conditioner (PTAC)
- Water loop heat pump (HP)
- Evaporative cooling system (EVAP-COOL)
- Central constant volume system (RHFS)
- Central VAV system (VAVS)
- Central VAV with fan-powered terminal boxes (PIU)
- Dual duct system (DDS)
- Multi-zone system (MZS)
- Unit heater (UHT)
- Four-pipe fan coil (FPFC)

Packaged HVAC system efficiency. Manufacturers’ data were gathered for the equipment surveyed based on the observed make and model number. A database of equipment efficiency and capacity data was developed from an electronic version of the ARI rating catalog. Additional data were obtained directly from manufacturers’ catalogs, or the on-line catalog available on the ARI website (www.ari.org). Manufacturers’ data on packaged system efficiency is a net efficiency, which considers both fan and compressor energy. DOE-2 requires a specification of packaged system efficiency that considers the compressor and fan power separately. Thus, the manufacturers’ data were adjusted to prevent “double-accounting” of fan energy, according to the procedures described in the 1995 Alternative Calculation Method (ACM) approval manual.

Pumps and fans. Input power for pumps, fans and other motor-driven equipment was calculated from motor nameplate hp data. Motor efficiencies as observed by the surveyors were used to calculate input power. In the absence of motor efficiency observations, standard motor efficiencies were assigned as a function of the motor hp, RPM and frame type. A rated load factor was used to adjust the nameplate input rating to the actual running load. For VAV system fans, custom curves were used to calculate fan power requirements as a function of flow rate in lieu of the standard curves used in DOE-2, as described in the 1995 ACM manual.

Refrigeration systems. Refrigeration display cases and/or walk-ins were grouped into three systems defined by their evaporator temperatures. Ice cream cases were assigned to the lowest temperature circuit, followed by frozen food cases, and all other cases. Case refrigeration loads per lineal foot were taken from manufacturers’ catalog data for typical cases. Auxiliary energy requirement data for evaporator fans, anti-sweat heaters, and lighting were also compiled from manufacturers’ catalog data. Model inputs were calculated based on the survey responses. For example, if the display lighting was surveyed with T-8 lamps, lighting energy requirements appropriate for T-8 lamps were used to derive the case auxiliary energy input to DOE-2.

Compressor EER data were obtained from manufacturers' catalogs as a function of the suction temperatures corresponding to each of the three systems defined above. These data were used to create default efficiencies for each compressor system. Custom part-load curves were used to simulate the performance of parallel-unequal rack systems.

Total heat of rejection (THR) data at design conditions were obtained for refrigeration system condensers from manufacturers' data. These data were used to calculate hourly approach temperatures and fan energy using the enhanced refrigeration condenser algorithms in DOE-2.1 E version 119.

Service hot water. Service hot water consumption was calculated based on average daily values from the 1995 ACM for various occupancy types. Equipment capacity and efficiency were assigned based on survey responses.

Exterior lighting. Exterior lighting input parameters were developed similarly to those for interior lighting. The exterior lighting connected load was calculated from a fixture count, fixture identification code and the input wattage value associated with each fixture code.

Plant

This section describes the methodology used to develop DOE-2 input for the plant simulation. Principal data sources included the on-site survey, Title 24 documents, manufacturers' data, program data, and other engineering references.

Chillers. The DOE-2 input parameters required to model chiller performance included chiller type, full-load efficiency and capacity at rated conditions, and performance curves to adjust chiller performance for temperature and loading conditions different from the rated conditions. Chiller type was assigned based on the type code selected during the on-site survey. Surveyors also gathered chiller make, model number, and serial number data. These data were used to develop performance data specific to the chiller installed in the building. Program data and/or manufacturers' data were used to develop the input specifications for chiller efficiency.

Cooling towers. Cooling tower fan and pump energy was defined based on the nameplate data gathered during the on-site survey. Condenser water temperature and fan volume control specifications were derived from the on-site survey responses.

Appendix B – Outdoor Lighting Impact Analysis

Title:

Statewide Impact of the California 2005 Energy Efficiency Standards for Commercial Outdoor Lighting
March 18, 2003, Edited June 13, 2003 by Eley Associates with permission of RLW

Prepared by:

RLW Analytics

Executive Summary

RLW Analytics, Inc has been asked to estimate the statewide impact of the outdoor lighting standards proposed for the 2005 Building Energy Efficiency Standards. This work was completed under the direction of Eley Associates, under contract to the California Energy Commission. The proposed standards that are analyzed in this report are published in the 2005 Energy Efficiency Standards for Commercial Outdoor Lighting, Feb 4, 2003[22].

The analysis was performed by applying the proposed standards to the California Outdoor Lighting Baseline Assessment database and model[23]. This model describes the use of commercial outdoor lighting statewide. The use of this model to evaluate the proposed outdoor lighting standard has allowed the detailed estimation of the statewide impacts presented in this report.

The impacts are determined for both electricity consumption and demand. Outdoor lighting has no impact on gas consumption. The total first-year energy savings are projected to be 20,985 mWh, 30% of the total energy consumption for these lighting applications. The total first-year demand savings are estimated to be 6,344 mW, 35% of the total demand at the winter peak nighttime hour. No demand savings are expected for the summer peak, which occurs during daylighted hours. These savings are for the first year and would double in the second year, triple in the third three year, 10 times in the tenth year, etc.

Savings are concentrated in three lighting applications, parking lots and hardscape, driveways and walkways, and signs (internally and externally illuminated). The applications that experience the least impacts include outdoor sales and outdoor sales frontage (which includes car dealerships), sales canopies (excluding gas station canopies), and non-sales canopies.

The standards require that controls be installed so that outdoor lighting can be turned off or reduced during a voluntary reduction. However, the standards do not require voluntary reductions. Therefore, the associated energy and demand savings are estimated separately. Table B1 below presents the statewide impacts of the measures alone, and with the impact of the voluntary reduction. The voluntary reduction is assumed to be in effect from dusk to dawn and has a duration of 30 days.

[22] 2005 Energy Efficiency Standards for Residential and Nonresidential Buildings Workshop Draft #3, Feb 4, California Energy Commission, http://www.energy.ca.gov/2005_standards/documents/index.html

[23] This report was completed by RLW Analytic, Inc on November 8, 2002 and submitted the New Buildings Institute (NBI) contractor to the California Energy Commission Public Interest Energy Research (PIER) Program. It can be downloaded from the NBI website: www.newbuildings.org.

Table B1 – Statewide Impacts

	Energy Consumption (MWh)	Energy Demand (MW)
Current Practice	69832.81	18.185
Measures Applied	48848.11	11.841
Impact of Measrures	20984.7	6.344
Savings Relative to Current Practice	30%	35%

These results are presented in Figure B1 below by lighting application. The horizontal scale represents energy savings in mWh per year (cumulative). Hardscape and parking lots have the greatest consumption of all the lighting applications included in the proposed standards. Driveway and walkways are responsible for the greatest savings when the proposed standard is applied.

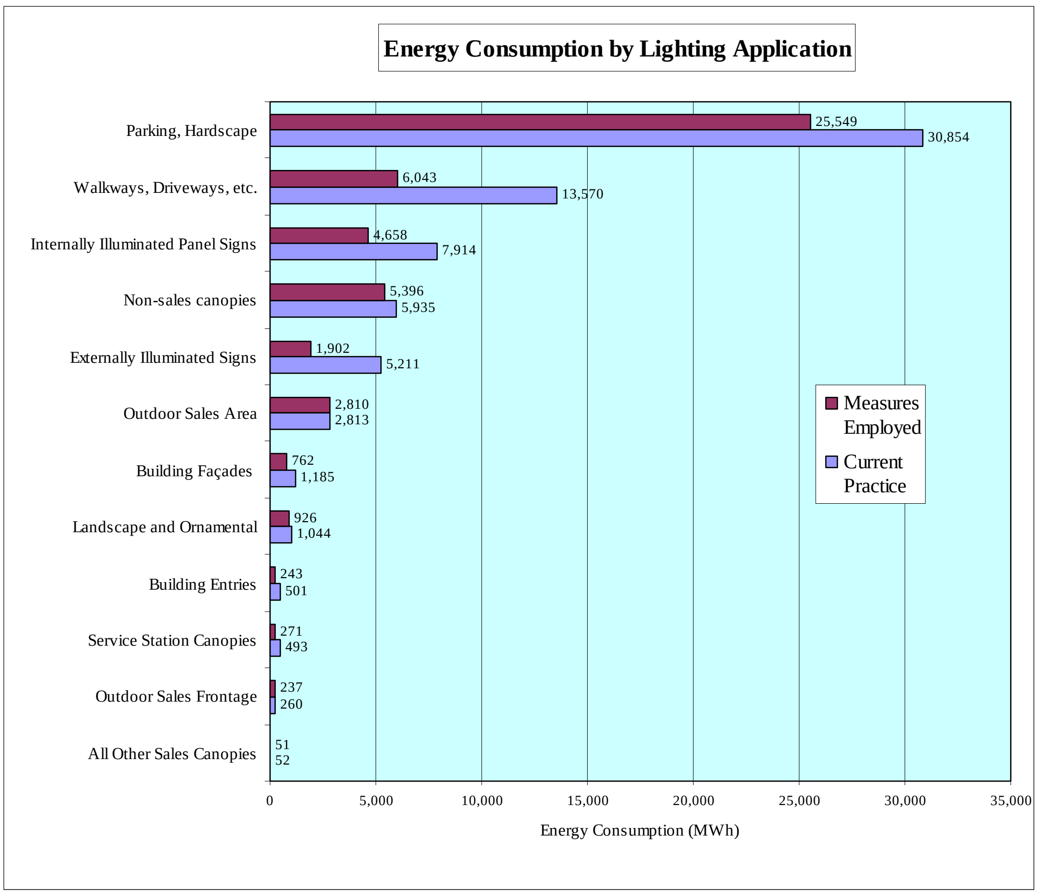

Figure B1 – Statewide Energy Consumption Comparison

The energy consumption impacts are dependent on two factors, the requirements of the proposed standard relative to current practice, and the intensity of the lighting application. Parking and other hardscape, for example, is responsible for the greatest annual energy usage because of the intensity of the application. While walkways have less annual energy consumption, they are responsible for the greatest energy savings (percent reduction) due to the requirements of the Standards.

The results are investigated in greater detail and presented in the tables within the Findings section of this report. The methodology and assumptions are detailed in the Methodology section. This section also includes the proposed lighting power allowances used in determining the impact of the standards.

Findings

The energy and demand impacts of the proposed standards are presented in Table B2 below. Hardscape including parking lots consume the most energy. However, driveways, walkways etc. provide the greatest energy impact of 7,526 mWh, and the greatest demand impact of 2,366 kW. The impact on outdoor sales areas is small as current practice is often below the proposed standards. The impact on all "other sales canopies" is small due to the limited representation of these areas in the baseline database. These findings are presented in greater detail in the following tables.

Table B2 – Statewide Energy Consumption and Demand Impacts

Annual Energy and Demand Impacts	Demand Savings	Energy Savings	Original Energy Consumption
	kW	MWh	MWh
Hardscape including parking lots	1,827	5,305	30,854
Driveways, Site Roads, Sidewalks, Walkways and Bikeways	2,366	7,526	13,570
Internally Illuminated Panel Signs	848	3,256	7,914
Non-sales canopies	154	539	5,935
Externally Illuminated Signs	863	3,309	5,211
Outdoor Sales Area	1	4	2,813
Building Façades	127	423	1,185
Landscape and Ornamental Lighting	31	118	1,044
Building Entrances (without canopy)	61	258	501
Vehicle Service Station Canopies	61	222	493
Outdoor Sales Frontage (Frontage in linear feet)	4	23	260
All Other Sales Canopies	0	1	52

Energy Consumption Impacts

Table B3 through Table B6 provide more detail on the energy and demand impacts.

Table B3 – First-year Energy Consumption Impacts as Percentage of Total Consumption

This table presents the energy impacts in greater detail. The last column, "Savings as Percent of Lighting Application Consumption," provides an indication of the stringency of the proposed standard relative to the current design practice for lighting application. Driveways, building entrances, and externally illuminated signs all experience an impact of more than 50%. Vehicle service station canopies and internally illuminated signs are close at 45% and 41% impact. Notably, the outdoor sales area classification has a low (0.1%) impact indicating current practice is often within the proposed allowables.

Annual Energy Impacts	Baseline Annual Energy Consumption (New Construction)	Total Energy Impact due to new standards	Savings as Percent of Lighting Application Consumption
Lighting Standard	kWh	kWh	%
Hardscape including parking lots	30,854,073	5,305,346	17.2%
Driveways, Site Roads, Sidewalks, Walkways and Bikeways	13,569,535	7,526,475	55.5%
Building Entrances (without canopy)	501,172	258,354	51.6%
Outdoor Sales Area	2,813,184	3,569	0.1%
Building Façades	1,185,224	422,930	35.7%
Outdoor Sales Frontage (Frontage in linear feet)	260,156	22,995	8.8%
Vehicle Service Station Canopies	492,896	221,954	45.0%
All Other Sales Canopies	52,031	1,079	2.1%
Non-sales canopies	5,934,877	538,868	9.1%
Landscape and Ornamental Lighting	1,044,413	117,975	11.3%
Internally Illuminated Panel Signs	7,914,108	3,256,162	41.1%
Externally Illuminated Signs	5,211,146	3,308,991	63.5%
Total	69,832,813	20,984,698	30%

Table B4 – Energy Consumption Impacts by Lighting Zone

This table explores the energy impact of each lighting application by lighting zone. The greatest savings for most of the applications occur within LZ3 due to the large percentage of statewide commercial activity within this zone[24]. While the areas assumed for LZ1 and LZ4 are equivalent for each (1%), the energy impacts of LZ1 are significantly higher than LZ4 due to the much more stringent lighting power allowances for this lighting zone which addresses government designated recreational areas and wildlife preserves.

Annual Energy Impacts	Energy Impact by Lighting Zone (kWh)				Total Energy Impact (kWh)
Lighting Standard	LZ1	LZ2	LZ3	LZ4	All Lighting Zones
Hardscape including parking lots	129,921	830,303	4,328,112	17,011	5,305,346
Driveways, Site Roads, Sidewalks, Walkways and Bikeways	104,905	266,756	7,087,408	67,405	7,526,475
Building Entrances (without canopy)	3,466	35,562	217,228	2,098	258,354
Outdoor Sales Area	1,967	1,602	0	0	3,569
Building Façades	11,852	26,911	381,120	3,047	422,930
Outdoor Sales Frontage (Frontage in linear feet)	2,602	5,476	14,918	0	22,995
Vehicle Service Station Canopies	3,345	18,665	198,830	1,114	221,954
All Other Sales Canopies	520	555	0	3	1,079
Non-sales canopies	27,600	136,038	371,928	3,302	538,868
Landscape and Ornamental Lighting	10,444	0	107,219	312	117,975
Internally Illuminated Panel Signs	79,141	133,024	3,008,098	35,899	3,256,162
Externally Illuminated Signs	42,935	132,147	3,097,104	36,804	3,308,991
Totals	418,698	1,587,039	18,811,966	166,996	20,984,698

[24] See the methodology section for the lighting zone percentages by lighting application.

Table B5 – Lighting Zone Impacts as Percentage of Total Consumed

This table shows the lighting zone results as a percentage of total energy impact for the associated lighting application. The results reinforce the observation that lighting zone 3 is responsible for the greatest impact, 90.95% overall. It is notable that the LZ3 impact is near 0% for outdoor sales areas, outdoor sales frontage, and all other sales canopies which suggests that the current practice for these applications is often within the proposed LZ3 allowable.

Annual Energy Impacts	Energy Impact by Lighting Zone as Percentage of Total Standard Impact				Savings as Percent of Lighting Application Consumption
Lighting Standard	LZ1 %	LZ2 %	LZ3 %	LZ4 %	All Lighting Zones
Hardscape including parking lots	0.42%	2.69%	14.03%	0.06%	17.2%
Driveways, Site Roads, Sidewalks, Walkways and Bikeways	0.77%	1.97%	52.23%	0.50%	55.5%
Building Entrances (without canopy)	0.69%	7.10%	43.34%	0.42%	51.6%
Outdoor Sales Area	0.07%	0.06%	0.00%	0.00%	0.1%
Building Façades	1.00%	2.27%	32.16%	0.26%	35.7%
Outdoor Sales Frontage (Frontage in linear feet)	1.00%	2.10%	5.73%	0.00%	8.8%
Vehicle Service Station Canopies	0.68%	3.79%	40.34%	0.23%	45.0%
All Other Sales Canopies	1.00%	1.07%	0.00%	0.01%	2.1%
Non-sales canopies	0.47%	2.29%	6.27%	0.06%	9.1%
Landscape and Ornamental Lighting	1.00%	0.00%	10.27%	0.03%	11.3%
Internally Illuminated Panel Signs	1.00%	1.68%	38.01%	0.45%	41.1%
Externally Illuminated Signs	0.82%	2.54%	59.43%	0.71%	63.5%
Totals	2.00%	7.56%	89.65%	0.80%	100%

Table B6 – Impact by Lighting Application as a Percentage of LZ Baseline Usage

This table reconfigures the results to present the energy saved within each lighting zone as a percentage of the total baseline value for that lighting zone. For example, 100% of the energy used in LZ1 of Outdoor Sales Frontage is eliminated by the standard that states "not allowed" for this lighting zone[25]. Because this table is independent of amount of commercial activity, it provides an understanding of the relative stringency of each allowable relative to the maximum theoretical value for that lighting zone.

Lighting Application	Total Impact	Percentage of LZ total			
	kWh	LZ1	LZ2	LZ3	LZ4
Hardscape including parking lots	5,305,346	42.1%	33.4%	17.7%	5.5%
Driveways, Site Roads, Sidewalks, Walkways and Bikeways	7,526,475	77.3%	71.3%	61.6%	49.7%
Internally Illuminated Panel Signs	3,256,162	100.0%	45.1%	45.4%	45.4%
Non-sales canopies	538,868	46.5%	29.4%	7.9%	5.6%
Externally Illuminated Signs	3,308,991	82.4%	80.1%	70.5%	70.6%
Outdoor Sales Area	3,569	7.0%	0.8%	0.0%	0.0%
Building Façades	422,930	100.0%	27.6%	40.6%	25.7%
Landscape and Ornamental Lighting	117,975	100.0%	0.0%	12.2%	3.0%
Building Entrances (without canopy)	258,354	69.2%	62.1%	57.0%	41.9%
Vehicle Service Station Canopies	221,954	67.9%	54.1%	44.3%	22.6%
Outdoor Sales Frontage (Frontage in linear feet)	22,995	100.0%	30.1%	6.3%	0.0%
All Other Sales Canopies	1,079	100.0%	9.0%	0.0%	0.7%

Energy Demand Impacts

The demand impacts are presented in the tables that follow. The demand impact results follow the patterns described in the preceding energy impacts tables. The demand impact was determined for the winter at 8pm, the time of greatest outdoor lighting usage.

[25] See Table B9 Proposed Lighting Standards for the lighting application allowables for each lighting zone.

Table B7 – First-year Winter Peak Demand Impacts as Percentage of Total Demand

This table presents the demand impact by lighting application, and provides the impact as a percentage of the total demand of each lighting application. Driveways and walkways experience the greatest impacts, while outdoor sales, which includes car dealerships, and "all other sales canopies" produce the least demand savings.

Annual Demand Impacts	Baseline Annual Demand by Lighting Applicatin (New Contruction)	Standard Total Demand Savings	Savings as Percent of Lighting Application Demand
	kW	kW	%
Hardscape including parking lots	8,095.4	1,827.2	22.6%
Driveways, Site Roads, Sidewalks, Walkways and Bikeways	3,998.6	2,366.3	59.2%
Building Entrances (without canopy)	147.9	61.1	41.4%
Outdoor Sales Area	662.1	0.8	0.1%
Building Façades	342.8	126.5	36.9%
Outdoor Sales Frontage (Frontage in linear feet)	62.5	3.7	5.9%
Vehicle Service Station Canopies	137.9	60.8	44.1%
All Other Sales Canopies	7.7	0.4	5.7%
Non-sales canopies	1,468.4	154.4	10.5%
Landscape and Ornamental Lighting	256.5	31.2	12.2%
Internally Illuminated Panel Signs	1,811.8	848.2	46.8%
Externally Illuminated Signs	1,193.0	863.2	72.4%
Total	18,184.5	6,343.8	35%

Table B8 – Percentage of Commercial Activity by Climate Zone

This table applies the statewide impact of the standards to the 16 climate zones. The percentages of newly constructed buildings by climate zone were derived from the Non-Residential New Construction (NRNC) database developed by RLW and Architectural Energy Corporation (AEC).[26] This study utilized the F. W. Dodge database to determine newly constructed building activity in the State of California.

Energy Impact by Climate Zone	Representative City	Percentage of New Construction within Climate Zone	Climate Zone Impact kWh
1	Arcata	0.31%	65,053
2	Santa Rosa	7.01%	1,471,027
3	Oakland	15.86%	3,328,173
4	Sunnyvale	7.13%	1,496,209
5	Santa Maria	1.87%	392,414
6	Los Angeles	6.02%	1,263,279
7	San Diego	7.46%	1,565,458
8	El Toro	8.76%	1,838,260
9	Pasadena	10.36%	2,174,015
10	Riverside	8.43%	1,769,010
11	Red Bluff	1.40%	293,786
12	Sacramento	14.50%	3,042,781
13	Fresno	5.96%	1,250,688
14	China Lake	2.40%	503,633
15	El Centro	1.98%	415,497
16	Mount Shasta	0.55%	115,416
Total		100.00%	20,984,698

Methodology and Assumptions

The values and methodology for determining the new allowable wattages and areas were based on the language contained in the 2005 Energy Efficiency Standards for Residential and Nonresidential Buildings Workshop Draft #3, Feb. 4, Section 147. The version used for this analysis was downloaded January 14, 2003. Any changes to the standards after this date are not incorporated in this analysis. The Outdoor Lighting Baseline Assessment database was modified to match the requirements of the standards methodology where required. These modifications and assumptions are listed below. The detailed description of the methodologies employed in building the Outdoor Lighting Database can be found in the Outdoor Lighting Baseline Assessment[27].

Lighting Power Allowances

The task to determine the energy and demand impacts of the proposed outdoor lighting standard required the application of the proposed standards to the California Outdoor Lighting Baseline Assessment database and associated model. The specific standards were applied to the data to generate a basecase (current practice) and the proposed standards case. The difference between these two model results provided the energy and demand impact. The standards values are listed below in Table B9. These proposed lighting power density allotments for each lighting application by lighting zone are published in the 2005 Energy Efficiency Standards for Residential and Nonresidential Building Workshop Draft #3, Feb 4.

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[26] Values obtained by communication with the AEC project manager responsible for the ongoing NRNC study.

[27] This report was completed by RLW Analytic, Inc on November 8, 2002 and submitted the New Buildings Institute (NBI) on behalf of the California Energy Commission Public Interest Energy Research (PIER) Program. It can be downloaded from the NBI website: www.newbuildings.org.

Table B9 – Proposed Lighting Standards

Table 147-A: Lighting Power Allowances for General Site Illumination	Allowance (w/sqft unless otherwise noted)			
	LZ1	LZ2	LZ3	LZ4
Hardscape including parking lots	0.04	0.06	0.08	0.15
Driveways, Site Roads, Sidewalks, Walkways and Bikeways	0.04	0.06	0.08	0.15
Building Entrances (without canopy)	0.35	0.50	0.70	1.00
Outdoor Sales Area	0.35	0.70	1.25	2.00
Building Façades	Not allowed	0.18	0.35	0.50
Outdoor Sales Frontage (Frontage in linear feet)	Not allowed	22.5 w/lf	38.5 w/lf	55 w/lf
Vehicle Service Station Canopies	0.70	1.00	1.25	2.00
All Other Sales Canopies	Not allowed	0.70	1.00	1.25
Non-sales canopies	0.12	0.25	0.50	0.70
Landscape and Ornamental Lighting	Not allowed	0.01	0.02	0.04
Internally Illuminated Panel Signs	Not allowed	11.00	11.00	11.00
Externally Illuminated Signs	1.00	1.80	2.30	2.30

Definitions and Methods

"Lighting Zones" determine the allowable lighting power density for the lighting applications. The determination of baseline energy consumption, and associated standards impact, required the allocation of each lighting application area between the four lighting zones.

The zones are divided into two general conditions, rural (LZ1 and LZ2) and urban (LZ3 and LZ4). The relative distribution between these conditions was based on the percentage of urban and rural energy consumption determined from the baseline analysis, using the US Census definitions by census block. This analysis provided an overall distribution of 92% of the statewide energy consumption in urban areas, and 8% in rural areas. The census information is reported by census block but is actually determined at the larger census block group level. This methodology defines many rural blocks within urban block groups.

The baseline database allows for the determination of urban or rural classification at the site level for most lighting applications that have large sample sizes. However, the sample sizes for outdoor retail sales, gas station canopies, and outdoor sales frontage were too limited to determine a reliable estimate of urban and rural classification. For these lighting applications the statewide urban/rural ratio was used.

Information on the commercial activity for two of lighting zones, LZ1 (a subset of rural) and LZ4 (a subset of urban) is not available from the baseline database or published research. Therefore, an energy demand of 1% of the total new energy demand is assumed for each of these. The associated impact reported for each is calculated by determining the impact of the new standard applied to 100% of the newly constructed buildings, then by multiplying the result by 1%. For example: To determine the impact of the LZ1 standard on parking, the LZ1 standard is applied to all new parking area resulting in a impact of 12,992,100 kWh. However, the area of new parking within LZ1 is assumed to be 1%. Therefore, the impact of the LZ1 standard is (12,992,100 kWh) x 0.01 = 129,921 kWh.

Table B10 below presents the lighting zone percentages for each of the lighting applications. These percentages originated from the California Outdoor Lighting Baseline Assessment using data from the US Census.[28]

Table B10 – Statewide Commercial Activity by Lighting Zone

Lighting Zone Designations	New Construction Energy Consumption by Lighting Zones (Defined_by_US_Census)				% Urban
	LZ1 (Rural)	LZ2 (Rural)	LZ3 (Urban)	LZ4 (Urban)	All Zones
Lighting Application	kWh	kWh	kWh	kWh	%
Hardscape including parking lots	1.0%	8.2%	89.8%	1.0%	90.8%
Driveways, Site Roads, Sidewalks, Walkways and Bikeways	1.0%	2.2%	95.8%	1.0%	96.8%
Building Entrances (without canopy)	1.0%	12.1%	85.9%	1.0%	86.9%
Outdoor Sales Area	1.0%	7.0%	91.0%	1.0%	92.0%
Building Façades	1.0%	8.4%	89.6%	1.0%	90.6%
Outdoor Sales Frontage (Frontage in linear feet)	1.0%	7.0%	91.0%	1.0%	92.0%
Vehicle Service Station Canopies	1.0%	7.0%	91.0%	1.0%	92.0%
All Other Sales Canopies	1.0%	12.6%	85.4%	1.0%	86.4%
Non-sales canopies	1.0%	7.9%	90.1%	1.0%	91.1%
Landscape and Ornamental Lighting	1.0%	2.6%	95.4%	1.0%	96.4%
Internally Illuminated Panel Signs	1.0%	3.3%	94.7%	1.0%	95.7%
Externally Illuminated Signs	1.0%	2.6%	95.4%	1.0%	96.4%

Antiquated technologies: The Outdoor Lighting Baseline Assessment database was reviewed for antiquated methodologies and equipment. However, all equipment reported in the study is currently available. While there are clearly inappropriate applications of outdoor lighting, there is no indication that these practices have been discontinued in current lighting configurations. Therefore, all data in the Outdoor Lighting Baseline Assessment database is considered to be applicable for the evaluation of newly constructed buildings.

Lighting Applications

Vehicle Service Station Canopies include only newer modern gas stations. The older gas station canopies were reclassified as “all other sales canopies”. This allowed a more accurate representation of the vehicle service station canopies in the results.

Outdoor Sales Frontage is an entirely new lighting application that required conversion of the baseline methodology. The area assigned as “frontage” was the sales area edge along the “principal viewing area” multiplied by 3 times the luminaire height. This area was deducted from the area defined as “outdoor retail sales”. No more than one edge was defined as frontage.

Because the database is based on area for each lighting application, the areas had to be converted to linear feet as specified by the standard. Area was converted to a linear ft value by dividing by 50 ft (2.5 times the assumed luminaire height of 20ft). For example, a frontage area of 15,000 sqft would be converted to 300lnft (15,000/50). If the installed wattage for the frontage area is 12,000 watts, the LPD would be 40 watts/lnft..

Hardscape includes parking lots, security lighting and storage area lighting. These were reported separately in the baseline report.

[28] U.S. Census Bureau: www.factfinder.census.gov

Walkway areas were converted to linear feet by assuming a typical width of 6 feet. The areas recorded within the baseline assessment for this application were divided by 6 to convert to linear ft. Method 1 of the standard defines the area to include 5 feet on either side of the walkway. Therefore the baseline areas were converted to the code equivalent by multiplying the baseline area by (5+6+5)/6.

Non-sales Canopies draw baseline data from a wide range of lighting applications. The standard specifies that the "illuminated area is defined as any area within a square pattern… less any that is under a canopy". Therefore the lit parking area that is under a canopy is governed by the non-sales canopies standards, rather than the parking standards. Walkways and entries also have significant areas redefined as non-sales canopies for this analysis.

Landscape and Ornamental Lighting area calculations are based on the total area of the site.

Internally Illuminated Panel Sign baseline information is calculated from the measured area of the cabinet signs on each site. This recorded area was multiplied by 20 watts / sqft to determine the baseline energy consumption of each sign.

Conclusions

The application of the California Outdoor Lighting Baseline Assessment database and model to the proposed 2005 Energy Efficiency Standards for Commercial Outdoor Lighting has allowed the detailed estimation of the expected statewide impact. The total annual energy savings are projected to be 20,985 mWh, 30% of the total energy consumption for these lighting applications. The total demand savings are estimated to be 6,344 kW, 35% of the total demand at the winter peak nighttime hour.

These savings are concentrated in three lighting applications, parking lots and hardscape, driveways and walkways, and signs (internally and externally illuminated). The applications that experience the least impacts include outdoor sales and outdoor sales frontage (which includes car dealerships), sales canopies (excluding gas station canopies), and non-sales canopies.